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Beckman

Operating and Servicing Manual

Electronic Instruments Division

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MODEL 9010

FUNCTION GENERATOR

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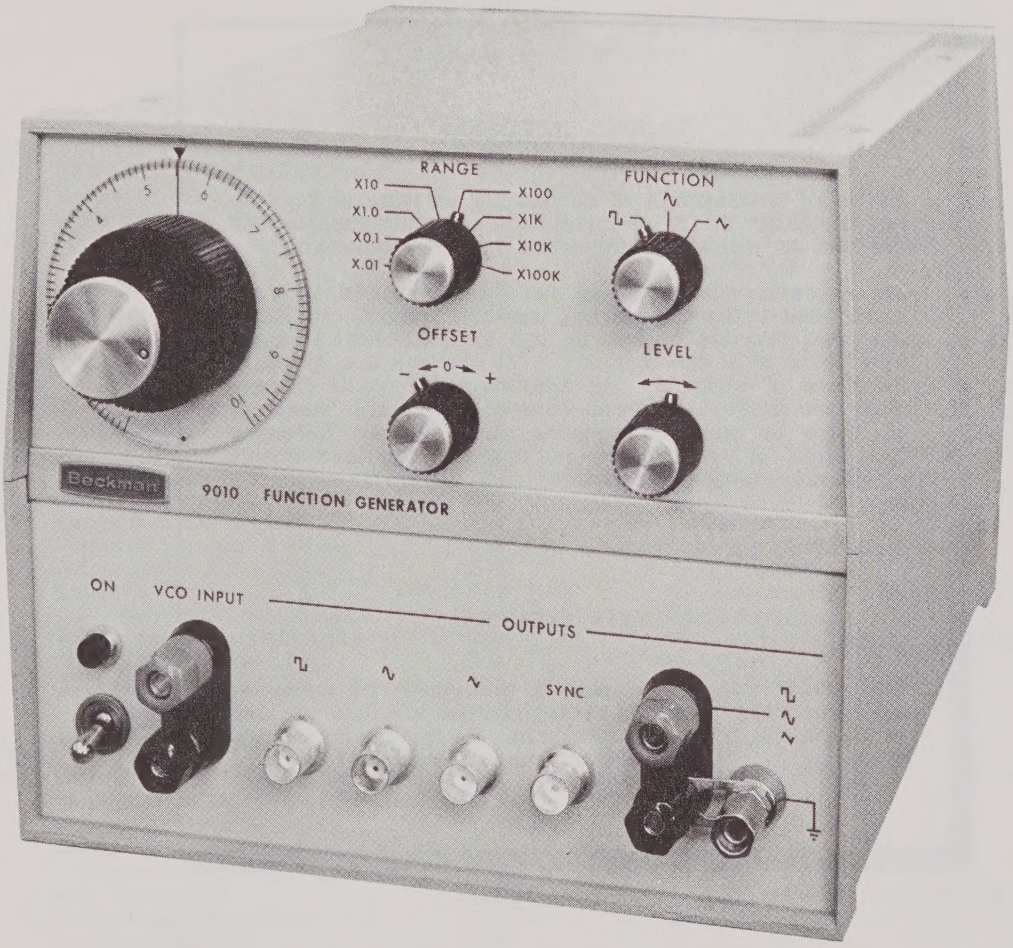

Model 9010 Function Generator

MANUAL REVISIONS

Beckman Instruments is continually striving to provide better quality in its products. As a result, changes are initiated to improve performance and specifications.

Several changes may have been incorporated in your instrument since the manual was last printed. If this is the case, may we impose on you to make these changes to your copy of the manual? All changes are given in the form of addenda, one addendum for each change. They are printed on green-colored paper and inserted, in letter or number sequence, immediately following this page. If a change does not apply to your instrument, please disregard the associated addendum.

PREFIX NUMBERS

The prefix number denotes a generation of manuals. All addenda for a certain prefix number are incorporated in the manual before reprinting and the number increased by one (e.g., "Prefix 500" becomes "Prefix 501").

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SECTION ONE

GENERAL DESCRIPTION

GENERAL

This instruction manual provides operating instructions for the Beckman Model 9010 Function Generator. This laboratory-type instrument generates sine, square, and triangular waves to cover the frequency spectrum from 0.005 Hz to 1 MHz. The output frequency is selected by means of an eight-position RANGE selector switch and a fine-frequency variable control. Provisions are made for controlling the frequency externally and for frequency modulating the output signals.

Any of the output signals are available from an internal power amplifier in amplitudes ranging from 0 to 30 volts peak-to-peak. The selected signal can be offset from -5 to +5 volts. The signals are also available simultaneously from buffer amplifiers at fixed amplitudes of 5 volts peak-to-peak. The square-wave output is compatible with integrated circuit (IC) logic levels. All outputs are short-circuit proof.

A sync pulse is available at the SYNC BNC connector. The leading edge of the sync pulse is coincident with the negative-going edge of the square wave. It is also coincident with the negative peaks of the selectable sine and triangular waves.

DESCRIPTION OF THE EQUIPMENT

The equipment is illustrated in the frontispiece. The front-panel controls are shown in Figure 2-1, and are described in Section Two of this manual. The equipment is enclosed in a drip-tight, two-section, cubical metal enclosure. Each section is secured to an internal frame by means of four machine screws. Removal of the upper section exposes the front-panel controls and the components side of the printed-circuit board. All of the electronics are contained on this board.

Removing the lower section provides access to the power transformer, a barrier-type terminal strip, the output connectors, and the etched side of the printed-circuit board. The connections at the terminal strip are for connecting the instrument for either 115-VAC or 230-VAC line operation.

SPECIFICATIONS

FREQUENCY

Range: 0.005 Hz (200 sec) to 1 MHz (1 microsecond)

Multiplier Setting	Dial Range
x0.01	0.005 Hz to 0.10 Hz
x0.1	0.05 Hz to 1.0 Hz
x1.0	0.5 Hz to 10 Hz
x10	5 Hz to 100 Hz
x100	50 Hz to 1 KHz
x1,000	500 Hz to 10 KHz
x10,000	5,000 Hz to 100 KHz
x100,000	50,000 Hz to 1 MHz

Accuracy: 1% of full scale 0.005 Hz to 100 KHz

2% of full scale 100 KHz to 1 MHz

Stability: ±0.05% of setting per 10 minutes

±0.25% of setting per 24 hours

Temperature Coefficient: ±0.1%/°C

Jitter: 0.025% cycle to cycle

Vernier: Provides 6:1 improvement in frequency settability

External Voltage Control

Frequency Range - 20:1

Sensitivity - 1 volt per major dial division (9.5 V for 20:1 change). Up to 50 V can be applied without damage to instrument.

Linearity - 0.1% frequency vs input voltage to 100 KHz

Input Impedance - Greater than 15 K ohms

OUTPUTS

Selectable Outputs (Square, Sinusoidal, Triangular)

Open Circuit: 30 V p-p signal adjustable 0 to ±5 V dc offset.

50-ohm Load: ±4.5 V peak maximum before clipping.

NOTE: For loads lower than 600 ohms, clipping will occur for high amplitudes and offsets.

Simultaneous Fixed Outputs

Square: >5 volts open circuit, positive, 50-ohm source; rise and fall times <10 ns.

Sine: >5 volts p-p open circuit, centered about ground, 50-ohm source.

Triangle: >5 volts p-p open circuit, centered about ground, 50-ohm source.

Sync: >10 volts, negative, <5μS wide.

General Output Specifications

Amplitude stability: ±0.05% per 10 min.
±0.25% per 24 hrs.

Offset stability: ±0.05% per 10 min.
±0.25% per 24 hrs.

Amplitude stability and Offset stability Temperature Coefficient:

±0.1%/°C

Amplitude Response: ±0.1 dB to 100 KHz
±0.5 dB 100 KHz to 1 MHz

Sine Wave Distortion: 1% to 100 KHz
2% 100 KHz to 1 MHz

Triangle Linearity: 1% to 100 KHz
5% 100 KHz to 1 MHz

Square Wave Response: Tilt less than 0.5%, Aberrations less than 5%. Selectable 30 V output rise and fall times less than 100 ns.

Time Symmetry: 1% below 0.1 Hz and above 100 KHz
0.5% from 0.1 Hz to 100 KHz

Note: 1. All specifications apply for 10% to 100% of full scale after 30 minutes warm up.

2. Unless otherwise noted, all specifications apply for operation from 20°C to 30°C. Derate all specifications by a factor of two for operation from 0°C to 20°C, or from 30°C to 55°C.

MECHANICAL

Dimensions:	7" high, 8" wide, 10" deep
Weight:	12 pounds
Temperature:	0 - 55°C
Power:	115/230 V ac ±10%, 50 to 400 Hz, 10 Watts

SECTION TWO

OPERATION

GENERAL

Procedures for operating the Model 9010 Function Generator in typical applications are contained in this section of the instruction manual. A functional description of the operating controls and connectors is presented first. All operating controls and connectors are on the front panel and are shown in Figure 2-1. In the text, all operating controls, control positions, and connectors are called out as they appear on the equipment.

OPERATING CONTROLS AND CONNECTORS

FINE FREQUENCY CONTROL

The fine frequency control is the dial on the top left side of the front panel. The dial is graduated in 95 linear increments whose relative values are from 0.5 to 10. The frequency control operates in conjunction with the RANGE selector switch. The output frequency is the product of the dial setting and the RANGE setting. For example, if the RANGE selector switch is set to the X.01 position and the frequency dial is set to 6.6, the output frequency is 0.066 Hz.

Note that by having a fine frequency control with 95 increments, there is an overlapping of frequency coverage between adjacent decade range.

The dial is rotated by means of two concentric knobs. The smaller knob drives the dial at a 6-to-1 ratio. The larger knob drives the dial directly.

RANGE SELECTOR SWITCH

The RANGE selector switch has eight distinct positions starting at X.01 and increasing by multiples of 10. For each setting of the RANGE selector switch, the frequency output can be varied from 0.5 to 10 times the value indicated on the RANGE switch setting. (See the preceding paragraph.)

FUNCTION SELECTOR SWITCH

The FUNCTION selector switch has three discrete positions that permit selection of the output signals. The switch positions are marked symbolically to indicate the type of signal output that is selected. The selected signal appears at the OUTPUT terminal posts.

OFFSET CONTROL

The OFFSET control displaces the main output signal from -5 volts to +5 volts. All output signals can be offset between these limits regardless of the amplitude of the signal. There is no interaction between the OFFSET and LEVEL controls.

LEVEL CONTROL

The LEVEL control adjusts the amplitude of the main output signal from 0 to approximately 30 volts peak-to-peak. This control has no effect on the amplitudes of the signals available at the OUTPUT BNC connectors. The amplitudes of these signals are fixed at approximately 5 volts peak-to-peak.

ON LIGHT AND TOGGLE SWITCH

The ON toggle switch, when in the up position, applies ac input power to the Model 9010 Function Generator. The application of ac power is indicated by the red ON light being lighted.

VCO INPUT TERMINAL POSTS (Voltage Controlled Oscillator)

The VCO INPUT terminal posts are used to introduce into the Function Generator an external signal to control the output frequency or to frequency modulate the output signal. Full frequency deviation requires 9.5 volts total swing of the VCO INPUT voltage.

The polarity and amplitude of the voltage

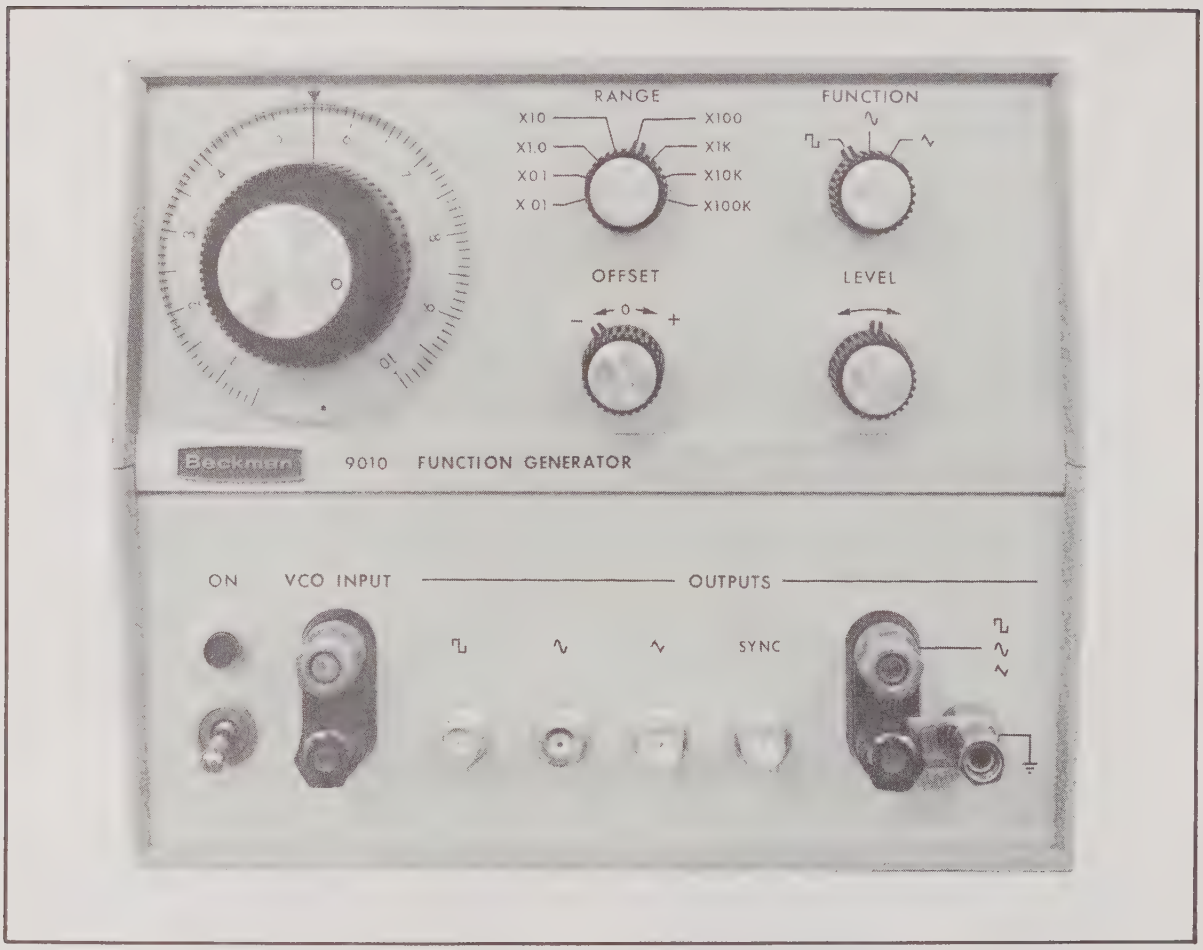


Figure 2 - 1. Operating Controls, Model 9010 Function Generator

applied to the VCO INPUT terminal posts is dependent upon the setting of the frequency dial. If the dial is set to 0.5, the external control voltage should be from 0 to +9.5 volts to cause a full frequency swing of the output signal. If the dial is set to 10, the external control voltage should be from 0 to -9.5 volts to get a full frequency swing of the output signal. Similarly, if the dial is set to 5.25, the external voltage should be from -4.75 to +4.75 volts to have the same effect on the output signal.

When frequency modulating a signal, the permissible frequency deviation from center frequency is also influenced by the frequency dial. Maximum frequency deviation is possible when the dial is set to 5.25 and a 9.5 V p-p modulating signal is used. Changing the frequency dial from the mid-range position decreases the permissible frequency deviation proportionally. The amplitude of the modulating signal must be reduced by the same proportion. Modulation rates as high as 100 kHz may be employed.

OUTPUT CONNECTORS

Four BNC connectors and a pair of terminal posts supply the output signals of the Model 9010 Function Generator. The signals available at the BNC connectors are clearly identified above the corresponding connector. These signals are available simultaneously. The amplitudes of the square wave, the sine wave, and the triangular wave are nominally 5 volts peak-to-peak. The square-wave output is compatible with the integrated-circuit logic levels. The source impedance of each output is nominally 50 ohms. The outputs are short-circuit proof.

The SYNC pulse has a 0-volt baseline and drops to -15 volts. Its negative-going, leading edge is coincident with the negative-going edge of the square wave. It is coincident with the negative peaks of the selectable sine and triangular waves. The SYNC pulse output is short-circuit proof.

The signal selected by the FUNCTION selector switch appears at the OUTPUT terminal posts. The amplitude of the selected signal can be adjusted by the LEVEL control from 300 millivolts to approximately 30 volts peak-to-peak. The output signal can be offset from -5 to +5 volts by means of the OFFSET control. The output source impedance is nominally 50 ohms. The output is short-circuit proof and current limited to 100 milliamperes.

The black VCO INPUT terminal post, the shield portion of the BNC connectors, and the black OUTPUT terminal post are isolated from the front panel. They are connected internally to the equipment "ground", and are normally connected to the chassis by means of the ground strap between the black OUTPUT terminal post and the ⏚ post.

In some applications it may be desirable to "float" the output. For these applications the ground strap between the black OUTPUT terminal post and the ⏚ post (cabinet ground) can be removed. With the strap removed, the unit is designed to accept up to 500 volts offset with respect to cabinet ground (common mode voltage).

Caution should be used when operating with the outputs floating, as the common mode voltage also exists between all other connectors and the cabinet. This is because the cabinet is connected to earth ground by the third wire in the ac line cord.

OPERATION

NOTE

The Model 9010 Function Generator operates on either 115 volts ac or on 230 volts ac. If the instrument is to be used on 230 volts, before applying power to the instrument, check the connections on terminal board TB1 and make sure it is connected for 230 volt operation. The connections are shown in Drawing No. 525831.

1. Set the OFFSET control to the midrange position.
2. Set the LEVEL control fully counter-clockwise.
3. Set the FUNCTION selector switch to the position that indicates the type of output signal required.
4. Select the output frequency with the RANGE selector switch and the frequency dial. Example: if the frequency dial is set to 7 and the RANGE switch is set to X100K, the output frequency is 700 KHz.
5. Connect the load to the OUTPUT terminal posts.
6. Set the ON toggle switch to the up position; observe that the ON indicating light is lit.
7. Monitor the output signal with an oscilloscope and adjust the LEVEL and OFFSET controls as desired.
8. If additional output signals are required, they may be obtained from the BNC connectors. All outputs from these connectors are available simultaneously.

SECTION THREE
PRINCIPLES OF OPERATION

GENERAL FUNCTIONAL DESCRIPTION

The Beckman Model 9010 Function Generator consists of seven functional sections: a voltage source, an integrator, a comparator, an electronic switch, a sinusoidal converter, an output amplifier, and the four auxiliary buffers. Figure 3-1 shows the interrelation of these functional sections.

VOLTAGE SOURCE

The voltage source produces accurate dc voltages -V and -V/2. These voltages are subsequently integrated to produce a ramp voltage, which is the basic internal signal source. All output signals are produced from the ramp voltage.

The voltage source is essentially a summing amplifier with two inputs. One input is a regulated dc voltage obtained from the wiper of the FREQUENCY variable control. The other input (VCO IN) permits external frequency control or frequency modulation of the output signal. For external frequency control operation, the signal must be a variable dc voltage whose total swing is 9.5 volts. For frequency modulation of the output signal, an external ac signal of 9.5 volts peak-to-peak (p-p) is required.

INTEGRATOR, COMPARATOR, AND ELECTRONIC SWITCH

The integrator, the comparator, and the electronic switch form a closed loop. Within this loop, a triangular wave and a square wave are produced. For this discussion, the operation of the loop is described beginning at a time when the electronic switch is connecting the -V output of the voltage source to the integrator. The electronic switch alternately connects the -V potential and zero volts to the integrator. Note that when -V is connected, the input to the integrator is -V/2. However, when the electronic switch grounds the input to the integrator, the potential at this point is effectively +V/2.

When -V connects to the integrator input, the effective dc voltage to the integrator causes the output to change linearly in a positive direction. This ramp voltage is compared with a pre-set level, and when both levels are equal, the comparator sends a signal to the electronic switch.

Acting upon the signal, the electronic switch disconnects the -V potential from the integrator and grounds its input. This causes a reversal of polarity of the ramp voltage produced by the integrator. The new ramp signal is again compared with a pre-set level. When the voltages are equal, the comparator sends a signal to the electronic switch, which ungrounds the input to the integrator and reconnects it to the -V. The cycle is then repeated.

Note that for fixed values of RC, the frequency of the triangular wave is a function of the amplitude of -V. Figure 3-2 illustrates three signals of different frequencies for different values of -V. In each case, the amplitudes are equal. This occurs because the comparator causes a reversal of polarity of the signal when the signal reaches the pre-set level of the comparator. The difference of frequencies occurs because the feedback capacitor charges at a faster rate for increasing values of -V.

SINE CONVERTER

The triangular-wave output of the integrator is the signal input to the sine converter. The sine converter derives a sine wave from the triangular wave. The conversion is accomplished by a loading process whereby diodes are switched into the circuit sequentially. Each diode loads the triangular wave sufficiently to modify it from a straight line to a sine function. The output of the sine converter is made available at the FUNCTION selector and is also available as the output of a buffer amplifier.

MAIN OUTPUT AMPLIFIER

The square-wave output of the comparator, the triangular-wave output of the integrator, and the sine-wave output of the sinusoidal converter are available at the FUNCTION selector switch. The signal that is selected can be

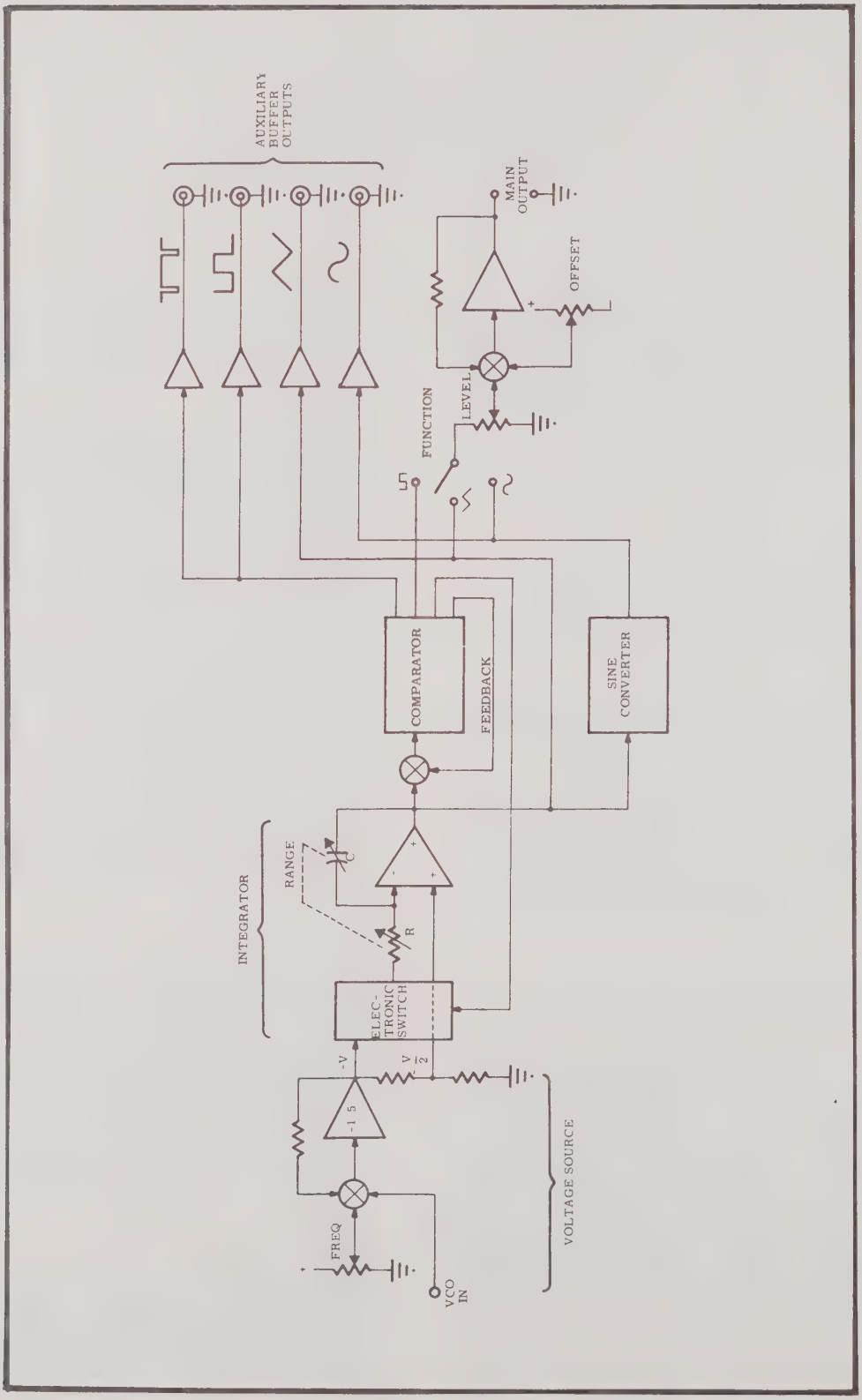


Figure 3 - 1. Model 9010 Function Generator Block Diagram

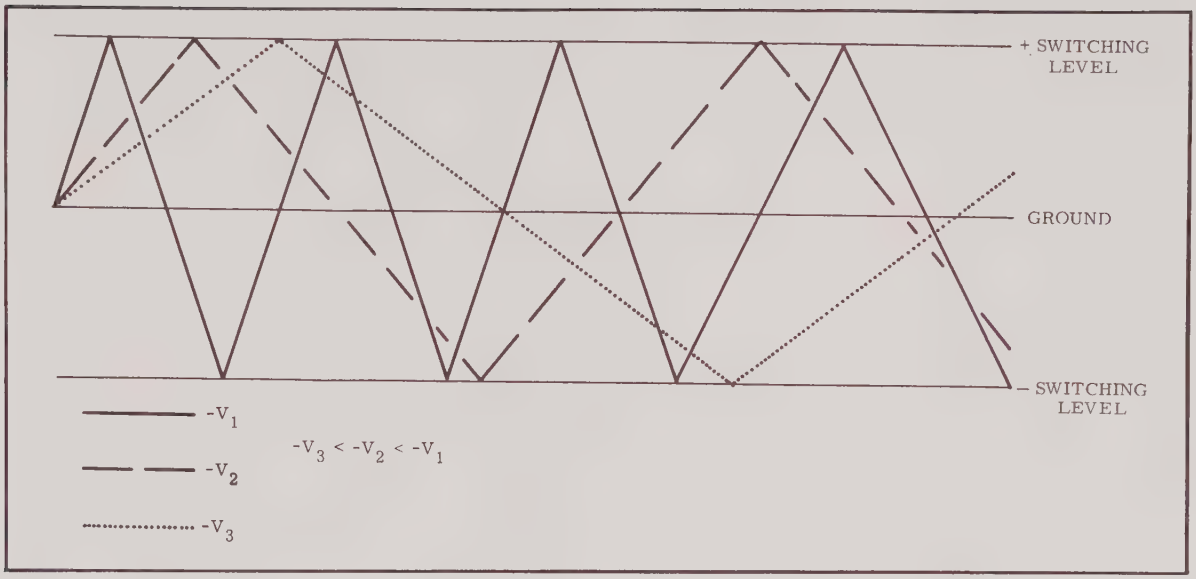


Figure 3-2. Frequency as a Function of -V

attenuated by the LEVEL control. The attenuated signal is summed with an offset voltage and amplified by the main output amplifier.

The main output amplifier provides power amplification for the selected signal. Maximum output is 30 volts peak-to-peak. The output impedance is nominally 50 ohms. Maximum current is limited to 100 milliamperes.

AUXILIARY BUFFERS

The four auxiliary buffers supply simultaneously the four output signals of the Model 9010 Function Generator. The buffers associated with the square wave, the triangular wave, and the sine wave reproduce the signals applied to them. The sync buffer, however, derives a narrow, negative-going sync pulse from the square wave.

The leading edge of the sync pulse is coincident with the negative peaks of the output selected triangular and sine waves. It is coincident with the negative-going edge of the output square wave. All outputs are short-circuit proof.

DETAILED CIRCUIT DESCRIPTIONS

VOLTAGE SOURCE

Figure 3-3 is a simplified schematic diagram of the voltage source. The circuit develops a constant dc voltage that is subsequently applied to the integrator. The circuit consists of a voltage regulator, a voltage divider, and an operational amplifier.

The voltage regulator is zener diode CR1. Resistor R1 supplies the zener current for the diode. The regulated output is 8.2 volts, and it appears across the voltage divider network. Deviations of power supply voltages, which affect the output of the voltage divider, are rejected by the zener diode.

The voltage divider consists of potentiometers R2 and R3, and resistors R4 and R5. The output voltage is variable between approximately 0.3 and 7.0 volts. These limits are set by potentiometer R2 (7.0) and resistors R4 and R5 (0.3). The output voltage, available at the wiper of the FREQUENCY potentiometer, drives the operational amplifier.

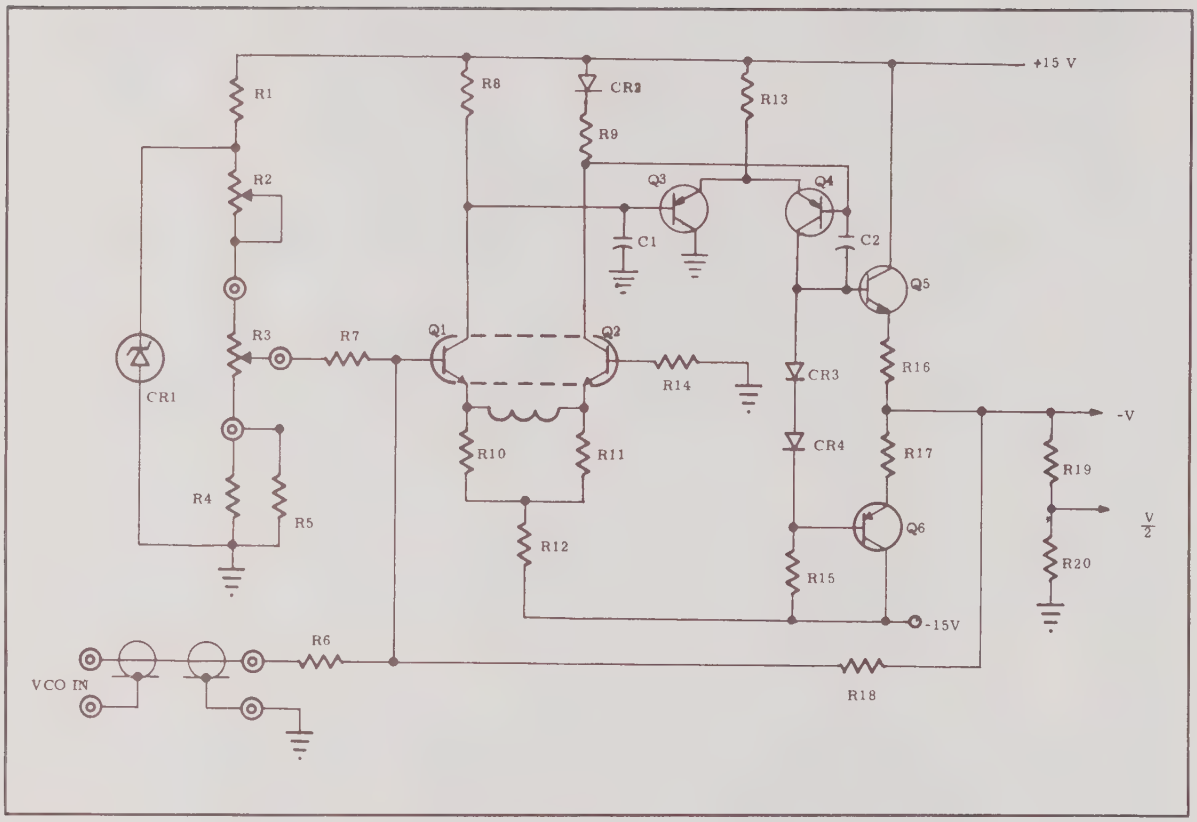


Figure 3 - 3. Voltage Source Simplified Schematic Diagram

The operational amplifier consists of a differential amplifier (Q1, Q2), a second differential pair (Q3, Q4), a complementary emitter-follower (Q5, Q6), feedback resistor R18, and summing resistors R6 and R7. It has an open-loop gain of approximately 5000. It has a closed-loop gain of approximately -1.5. Thus, the output voltage ranges from approximately -0.45 for the minimum setting of the FREQUENCY potentiometer, to -10.5 volts for its maximum setting. This voltage is applied through a transistor switch to the integrator. Half of this voltage, obtained at the junction of resistors R19 and R20, is applied to the plus input of the integrator. The dc voltage output of the voltage source can also be controlled externally. In such instances, a variable voltage whose total swing is 9.5 volts is applied to the VCO INPUT terminal posts.

The polarity and amplitude of the voltage applied to the VCO IN connector is dependent upon the setting of the FREQUENCY dial. If the dial is set at its minimum setting, the external control voltage should be from 0 to +9.5 volts to cause a full frequency swing of the output signal. Conversely, if the dial is set at its maximum position, the external control voltage should be from 0 to -9.5 volts to get a full frequency swing of the output signal. Similarly, if the dial is set to its midrange position, the external voltage should be from -4.75 to +4.75 volts to have the same effect on the output signal.

The external control voltage can also be used to frequency modulate the output signal. For any selected frequency range, full frequency deviation is obtained if the FREQUENCY dial is set to its midrange position, and a 9.5 volt

p-p sinusoidal signal is used. Modulation rates as high as 100 kc may be employed.

INTEGRATOR

Figure 3-4 is a simplified schematic diagram of the integrator. This circuit generates a linear triangular wave. The triangular wave is an output signal, and it is also the basic signal from which all of the other signals are derived. The circuit consists of a high-gain differential amplifier and a switchable RC network connected to form an integrator.

The differential amplifier consists of a Darlington-connected differential pair driving a second differential stage, and a complementary

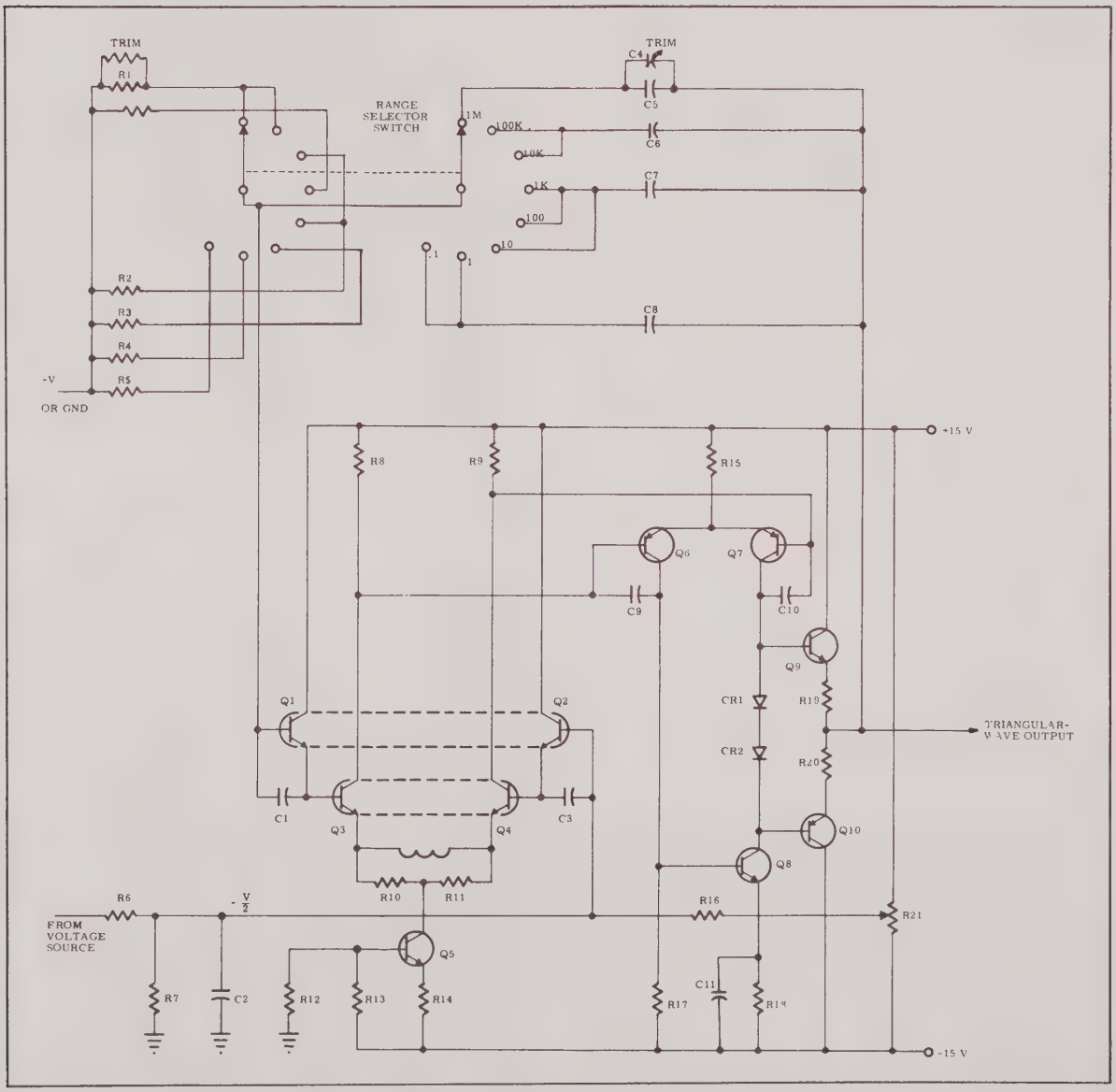


Figure 3 - 4. Integrator Simplified Schematic Diagram

emitter-follower. The switchable RC feedback network drives the minus input of the differential amplifier. The voltage divider at the output of the voltage source drives the plus input.

When the transistor switch (Page 3-7) is supplying the -V output of the voltage source to the integrator, the effective voltage input to the integrator is -V/2. The feedback capacitor charges in a direction to make the integrator output voltage change in a positive direction.

Conversely, when the transistor switch is grounding the input to the integrator, the effective voltage input to the integrator is +V/2. The feedback capacitor then charges in a direction to make the integrator output voltage change in a negative direction.

The switchable components of the feedback network are limited to six resistors and four capacitors. The capacitors and resistors are selected in different combinations to provide the wide operating range required. For the highest range, capacitor C5 (trimmed to approximately 220 pf by capacitor C4) is used with resistor R1 (trimmed to approximately 1150 ohms). For the 100 K and 10 K ranges, a 2200 pf capacitor (C6) is used in combination with two resistors. For the 1 K, 100, and 10 ranges, three resistors are used in different combinations with a 0.22-ufd capacitor (C7). Similarly, for the two lower ranges, a 5-ufd capacitor (C8) is used in combination with two resistors.

All of the capacitors are of the low-leakage type with very low temperature coefficients. The 0.22-ufd and the 5-ufd capacitors are of polycarbonate composition; the two smaller capacitors are molded mica.

Symmetry of the output signal is obtained by adjusting potentiometer R21. This control feeds a slight dc voltage of either polarity to the plus input of the integrator. Thus, any unbalance of the input circuit to the integrator can be compensated for. The unbalance arises mainly from slight differences in operating characteristics of the transistors in the transistor switch and from input offsets in the integrator.

COMPARATOR

Figure 3-5 is a simplified schematic diagram of the comparator. The circuit consists of an extremely-fast, IC, differential comparator and two transistor switches. Positive

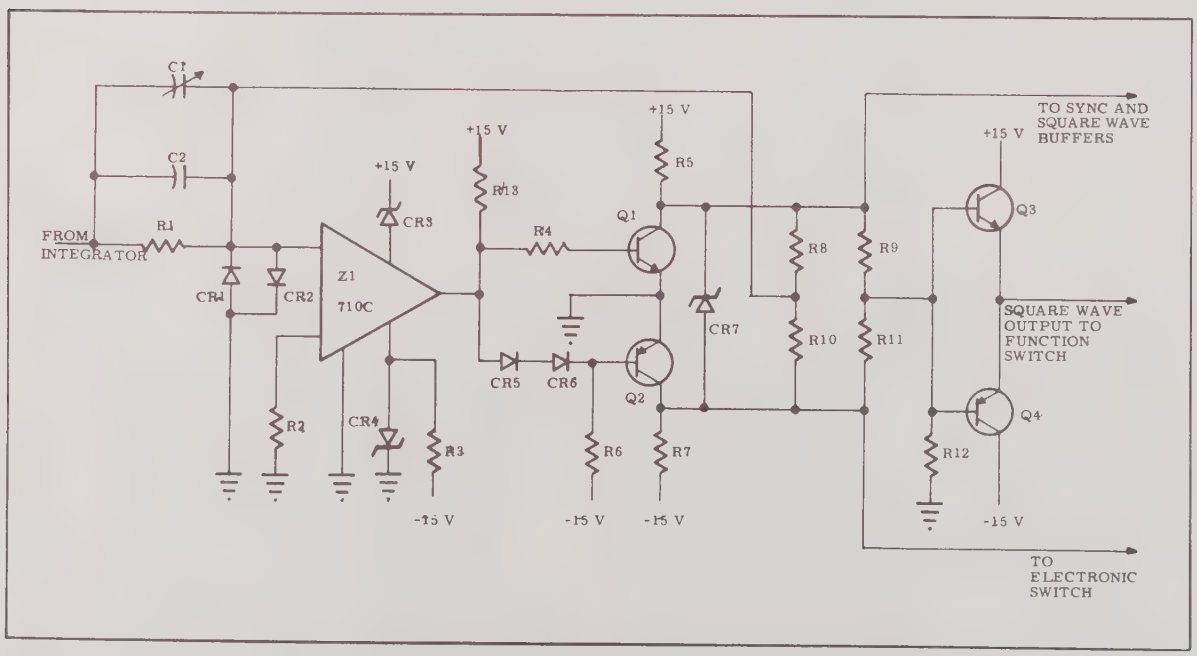


Figure 3 - 5. Comparator Simplified Schematic Diagram

feedback from the switches to the differential comparator produces hysteresis, such as in a Schmitt trigger.

The comparator senses the triangular-wave output of the integrator, compares this signal to a pre-set voltage level, and sends a signal to the electronic switch when the triangular-wave reaches the pre-set voltage level. As a result of the comparison, a square wave is produced. The square wave, after amplification, is an output of the instrument.

Transistor switches Q1 and Q2 alternate in their operation; both transistors cannot conduct simultaneously. A positive output from the comparator turns transistor Q1 on. Conversely, a negative output from the comparator turns transistor Q2 on. Assume that the comparator output has just switched negatively, turning transistor Q2 on. At this point, the input to the integrator is grounded, the output of the integrator is at its most positive excursion (approximately +5.5 volts), and the positive-feedback voltage at the collector of transistor Q1 is approximately +8.2 volts. This creates a current flow through resistors R1 and R8 to the +8.2 volts. As a result of this current flow, the comparator continues to produce a negative output, which maintains transistor Q2 turned on.

As the integrator output changes from +5.5 volts in a negative direction, the current flow through the above-mentioned resistors diminishes until there is no current flow, and then starts to flow in the opposite direction. Eventually, the input signal to the comparator is negative enough to overcome the threshold level of the comparator. The comparator output then switches from a negative polarity to a positive polarity.

When the output switches, transistor Q1 turns on quickly and transistor Q2 turns off. The collector of transistor Q2 goes from ground to -8.2 volts. The input to the integrator is connected to -V, and the triangular-wave output is at its most negative excursion (approximately -5.5 volts). A new comparison is thus started. The current flowing through the above-mentioned resistors (due to the positive feedback) keeps the comparator producing a positive output until a reversal of current flow occurs. Then the input swings positive enough to cause the output to switch. The action of the circuit is repetitive thereafter.

ELECTRONIC SWITCH

Figure 3-6 is a simplified schematic diagram of the electronic switch. The circuit is made

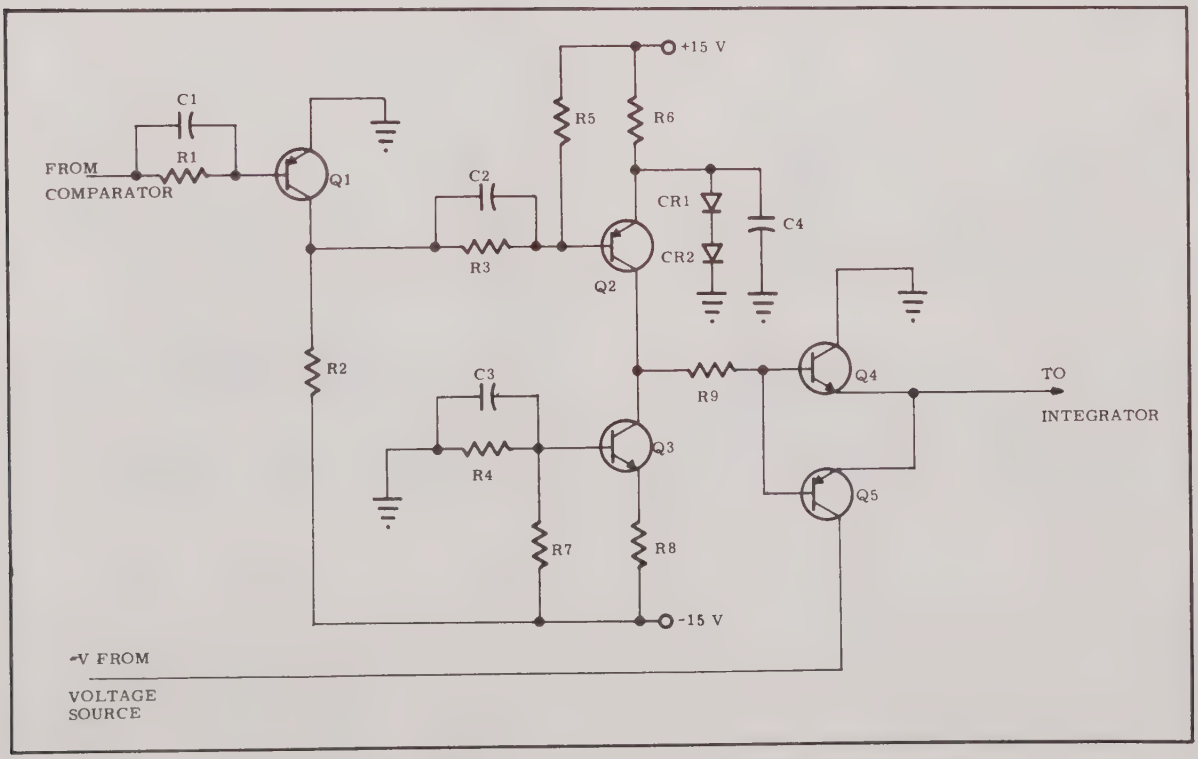


Figure 3 - 6. Electronic Switch Simplified Schematic Diagram

up of a switch driver (Q1, Q2, Q3) and a switch (Q4, Q5). The switch is essentially a SPDT switch. In one position, it connects the -V output of the voltage source to the integrator. In the other position, it grounds the input to the integrator.

The input signal to the switch driver is the negative-polarity, square-wave output of the comparator. The signal swings from 0 to -8.2 volts. When the input signal is -8.2 volts, transistor Q1 turns on. This action grounds the junction of resistors R2 and R3, and transistor Q2 cannot conduct. Constant current source Q3 turns on transistor Q5, closing the switch between -V and the integrator.

When the input signal is at ground level, transistor Q1 turns off, releasing the junction of resistors R2 and R3 from ground. The voltage divider network of R2, R3, and R5 forward-biases transistor Q2, turning it on. Transistor Q5 turns off, and transistor Q4 turns on. The -V output of the voltage source is thus disconnected from the integrator, and the input is grounded through transistor Q4.

SINUSOIDAL CONVERTER

Figure 3-7 is a simplified schematic diagram of the sinusoidal converter. The circuit derives a sine-wave output from a triangular-wave input. The conversion is accomplished by progressively loading the triangular wave as it changes amplitude.

The sinusoidal converter consists of eight diode limiters and a modified complementary emitter-follower. The diode limiters are biased at different voltage levels through a series of taps on a voltage divider network (resistors R1 through R12). Diodes CR1 through CR4 have positive bias voltages. Diodes CR5 through CR8 have negative bias voltages.

The input signal is applied to resistor R13. Assume that it is at ground level and is changing in a positive direction. The signal has no effect upon the diode limiters, and it is coupled through the emitter-followers to the output. After the triangular wave exceeds the bias level of diode CR4, the diode conducts and it places a slight load on the triangular wave. This decreases slightly the rate of change (slope) of the signal, and it starts converting from a straight line to a sine function.

As the signal amplitude continues to increase diodes CR3, CR2, and CR1 conduct in that sequence. Each diode, as it conducts, places an additional load on the signal. The result is that each load further changes the rate of change of the signal, and the resultant is a conversion from a straight line to a sine function.

By the time the signal reaches its maximum amplitude, the four diodes are conducting. They continue to load down the signal until it decreases sufficiently to back-bias the diodes. Thus, they turn off in succession in the reverse order that they turned on. When all diodes turn off, the positive half cycle of the triangular wave has been converted to a positive half cycle of a sine wave. The negative half cycle is similarly obtained.

The resultant sine wave passes through the emitter-follower to a buffer amplifier and to an RC filter network. The filter removes small spikes that occur at comparator switch times. The filtered signal is made available to the FUNCTION selector switch. It has typically less than 1/2 percent total harmonic distortion.

MAIN OUTPUT AMPLIFIER

Figure 3-8 is a simplified schematic diagram of the main output amplifier. The circuit provides power amplification to the signal selected by the FUNCTION selector switch. It is a wide-band, very-high-slewing-rate amplifier. It supplies a 30-volt p-p signal. The output impedance is 50 ohms. The output signal can be offset from -5 to +5 volts.

The input stage is a differential amplifier (Q1, Q2). This is followed by two common-emitter amplifiers (Q3, Q4) and an inverting stage (Q5). The output stage (Q6, Q7) is a complementary emitter-follower.

Resistor R11 feeds back the signal to the summing junction of resistors R2 and R4. The

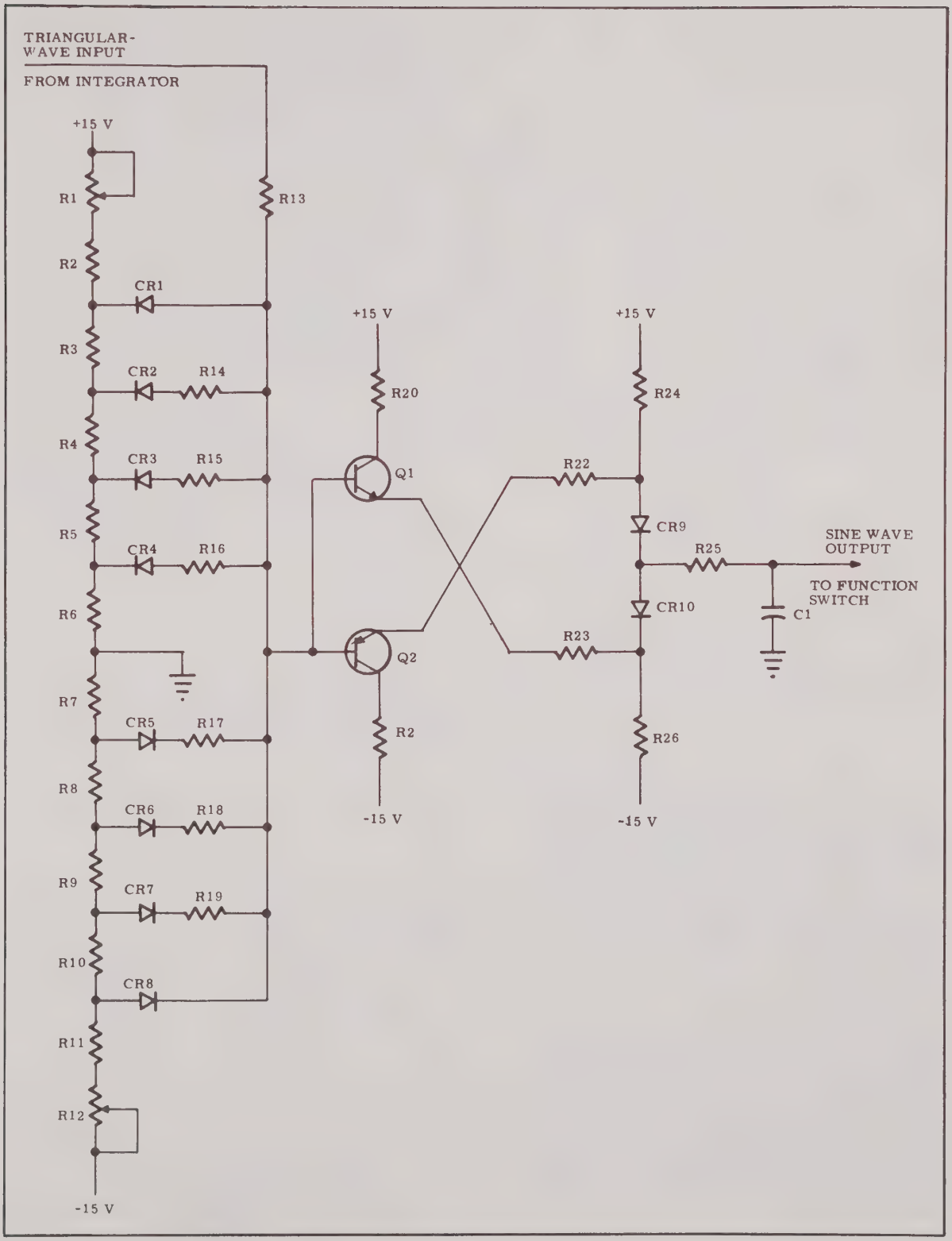


Figure 3 - 7. Sine-Wave Converter, Simplified Schematic Diagram

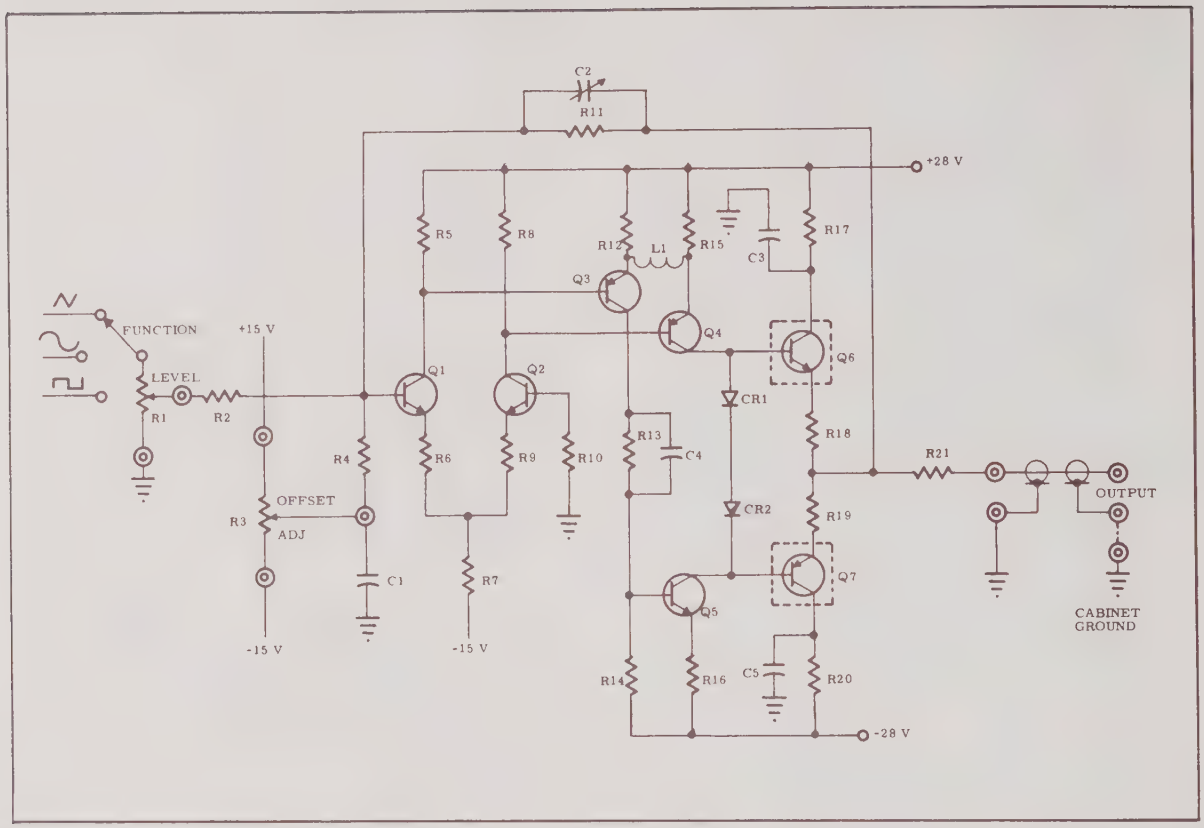


Figure 3 - 8. Main Output Amplifier Simplified Schematic Diagram

input to resistor R2 is the signal selected by the FUNCTION selector switch and adjusted in amplitude by the LEVEL control. The input signal to resistor R4 is the dc OFFSET voltage. The amplifier has a gain of approximately -5.5 for input signals to resistor R2. It has a gain of approximately -1/3 for the dc OFFSET voltage.

SYNC BUFFER

The sync buffer is shown schematically in Figure 3-9. The circuit generates a narrow pulse (approximately 0.5 microseconds) that rides on a 0-volt baseline and drops to -15 volts. The leading edge of the sync pulse is coincident with the negative-going edge of the output square wave. It is coincident with the negative peaks of the selected output triangular and sine waves.

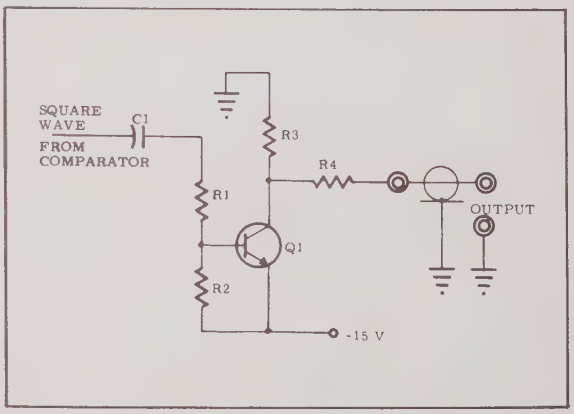


Figure 3 - 9. Sync Buffer Simplified Schematic Diagram

The input signal to the sync buffer is a square wave of approximately 8.2 volts p-p amplitude, which is generated by the comparator. Capacitor C1 and resistors R1 and R2 differentiate the square wave. The positive peaks of the differentiated signal drive transistor Q1 into saturation. This produces at the output a narrow pulse, shifting from ground level to -15 volts. The transistor is protected from overload by resistor R4.

SQUARE-WAVE BUFFER

The square-wave buffer is shown schematically in Figure 3-10. The circuit inverts the square-wave output of the comparator, buffers the signal, and provides power amplification. The output signal is approximately 5 volts peak-to-peak. The output impedance of the buffer is approximately 50 ohms.

The input signal, coupled by speed-up capacitor C1, quickly drives transistor Q1 into saturation. The inverted output of the transistor is then coupled through complementary emitter-followers to the output BNC connector. The output level shift is from ground to approximately +5 volts. It is compatible with integrated circuit (IC) logic levels.

SINE-WAVE AND TRIANGULAR-WAVE BUFFERS

The buffer amplifiers for the sine-wave and for the triangular-wave are schematically identical, but the values of the input resistors and the capacitor differ. Figure 3-11 shows the sine-wave amplifier. The circuit produces

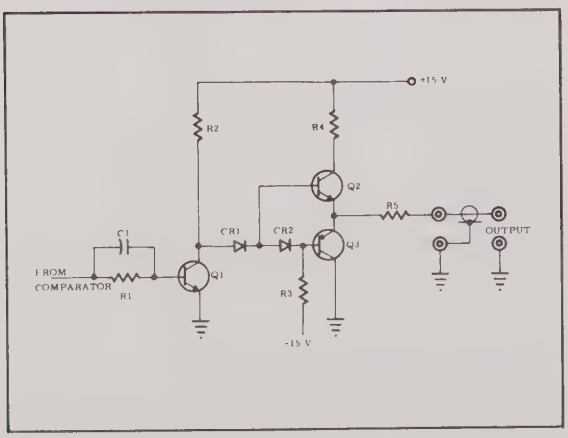


Figure 3 - 10. Square-Wave Buffer Simplified Schematic Diagram

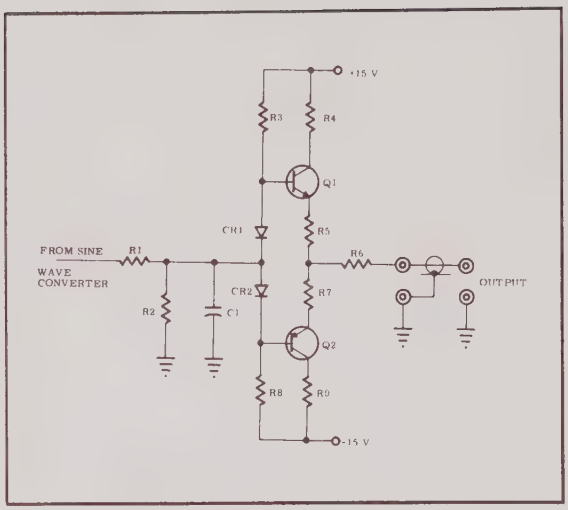


Figure 3 - 11. Sine-Wave Buffer Simplified Schematic Diagram

an output of approximately 5 volts peak-to-peak. Its output impedance is nominally 50 ohms.

The input signal is attenuated by resistors R1 and R2, and filtered by capacitor C1 to remove small spikes that occur at comparator switch times. The signal is then coupled by complementary emitter-followers to the output BNC connector.

POWER SUPPLY

Figure 3-12 is the schematic diagram of the power supply. The circuit operates from either 115-V or 230-V ac power, depending upon how the primary windings are connected. It supplies unregulated outputs of +28 and -28 volts, and regulated outputs of +15 and -15 volts.

The +28 and -28 voltages are derived from bridge rectifier diodes CR1 through CR4. Capacitors C1 and C2 filter the output voltages.

The +15 and -15 voltages are derived from bridge rectifiers CR5 through CR8. The voltages are filtered by capacitors C3 and C4 and controlled by their respective regulators. The regulator for the +15-volt supply consists of series-regulator Q1, emitter follower Q2, and control transistor Q3. The regulator for the -15-volt supply is functionally the same as the regulator of the +15-volt supply. The operation of the +15-volt regulator is described.

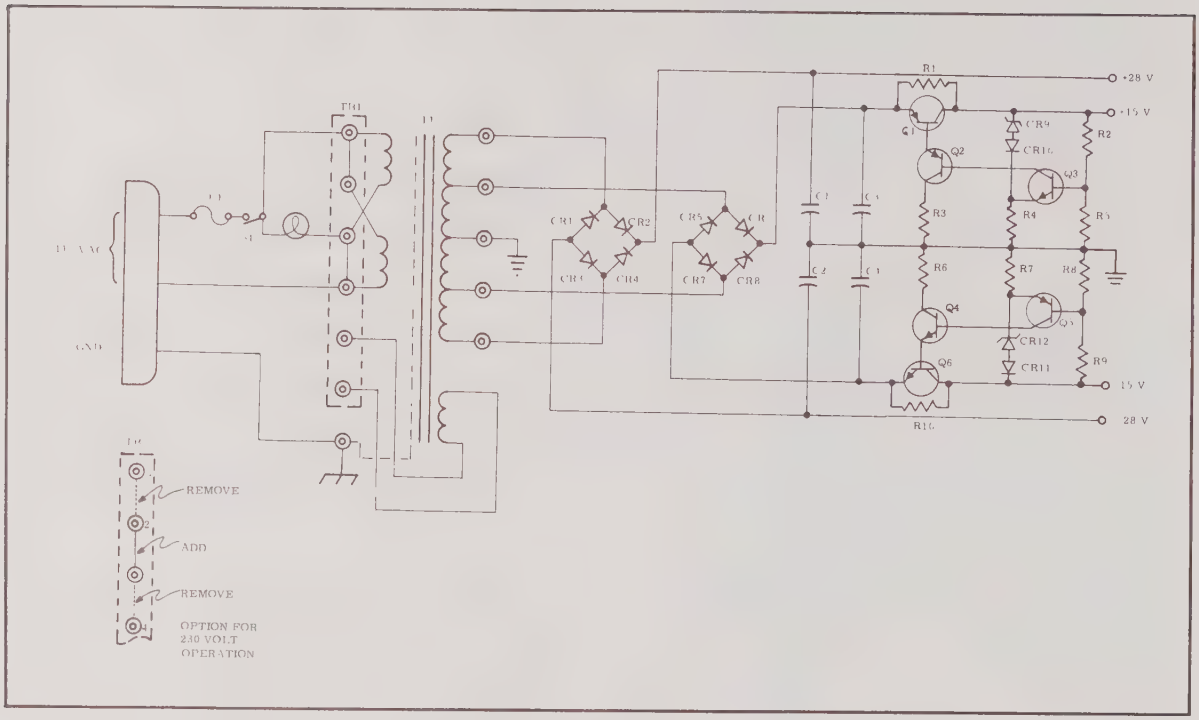


Figure 3 - 12. Power Supply Simplified Schematic Diagram

Proper regulation of the +15-volt supply hinges largely upon the current flow through transistor Q3. An increase of output voltage decreases conduction through the transistor and, conversely, a decrease of output voltage increases its conduction. Transistor Q2 follows the change of current flow in transistor Q3, but provides a current gain to drive series-regulator Q1. Transistor Q1 responds to the emitter follower and regulates the current flow to maintain the output at +15 volts.

SECTION FOUR

MAINTENANCE

GENERAL

This section describes the calibration and troubleshooting procedures for the Model 9010 Function Generator. Periodic maintenance is normally not required. The overall stability and reliability of the instrument is such that if it is used properly it will provide years of uninterrupted service.

CALIBRATION AND PERFORMANCE CHECKS

The following calibration and performance checks verify proper operation of the Function Generator. Each step of this procedure should be performed in the order given, as each step is based upon the previous step having been satisfactorily performed.

TEST EQUIPMENT REQUIRED

The test equipment that is required for maintaining and checking the Model 9010 Function Generator is listed below. Test equipment having equivalent characteristics can be substituted for the equipment listed.

a. Oscilloscope; Tektronix Model 545 with Type CA plug-in and X10 attenuation probe.

b. EPUT Meter; Beckman Model 6146.

c. Distortion Analyzer; Hewlett Packard Model 330D.

d. Multimeter; Simpson Model 269.

TEST PROCEDURES

Voltage and Frequency

1. Measure the following power supply voltages:

   E36 = 14.5V ±1.5V
   E37 = -14.5V ±1.5V

   Voltage across capacitor C8 = +30V ±5V
   Voltage across capacitor C9 = -30V ±5V

2. Turn the FREQUENCY dial to 5.0; set the RANGE switch to X1K; monitor TP-3; check for approximate triangle.

   +5.5V ±10%

   -5.5V ±10%

   If this waveform is not present, refer to Table 4-3.

3. Monitor the square wave output on the front panel through a 510Ω resistor with the EPUT meter. Adjust the EPUT trigger level until the EPUT meter indicates 5KHz ±20%.

   a. With the FREQUENCY dial at 10.0, adjust potentiometer R11 until the EPUT meter reads 10.000KHz ±25 Hz.

   b. Turn the FREQUENCY dial to 1.00 and select resistor R15 until the EPUT meter reads 1.000KHz ±25 Hz.

   c. Repeat steps a and b as necessary until both specifications are met.

Symmetry

1. Set the FREQUENCY to 1.00 X 10; attach both X & Y EPUT inputs to the square wave output via the 510Ω resistor.

2. Set START slope to + and STOP slope to - (EPUT should be ac coupled).

3. Set EPUT mode to TIME X-Y.

   a. Record the reading to + START and - STOP (approximately 50.0 ms).

   b. Change EPUT to - START and + STOP. Record reading (approximately 50 ms).

c. Adjust potentiometer R50 until reading a is equal to reading b within ±0.25 ms. Return the FREQUENCY to 10.0 X 1K and repeat the FREQUENCY checks (Page 4-1).

Frequency

1. Read and trim the frequencies indicated in Table 4-1; if within specifications, do not trim. Refer to Appendix A if trimming is required.

   a. Change the EPUT meter to Frequency Reading and check the frequencies indicated in Table 4-2.

Sine Wave Output

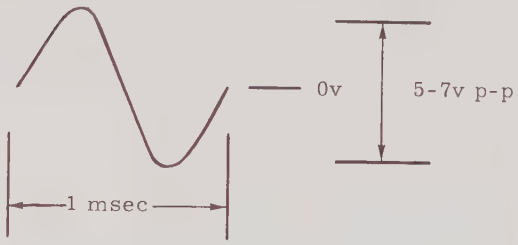
For all succeeding steps, the scope probe must be grounded at the correct respective connector.

1. Monitor the sine wave output at the ~ BNC Connector.

2. Set the FREQUENCY to 10.0 X 100. Attach the distortion meter on the output.

   a. Adjust potentiometers R51 and R52 for minimum distortion. Distortion should be less than 0.5%. The maximum acceptable value is 1%.

   b. After adjusting R51 and R52, the output should be approximately as follows:



   c. The output must be symmetrical about ground and between 5 and 7 volts peak-to-peak.

   d. Switch frequency to 10.0 X 100 K. The peak-to-peak voltage must be the same (±0.3V) as in step b.

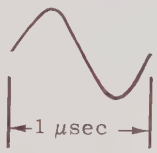


Table 4-1. Period Limits

SETTING	LOW LIMIT	NOMINAL	HIGH LIMIT
10.0 X 0.01	9.9 sec	10.0 sec	10.1 sec
10.0 X 0.1	0.99 sec	1.0 sec	1.01 sec
10.0 X 1.0	99.0 ms	100.0 ms	101.0 ms
10.0 X 10	9.9 ms	10.0 ms	10.1 ms
10.0 X 100	0.99 ms	1.00 ms	1.01 ms

Table 4-2. Frequency Limits

SETTING	LOW LIMIT	NOMINAL	HIGH LIMIT
10.0 X 1 K	9.9 KHz	10.0 KHz	10.1 KHz
10.0 X 10 K	99.0 KHz	100.0 KHz	101.0 KHz
10.0 X 100 K	0.99 MHz	1.00 MHz	1.01 MHz

e. The wave should be relatively free of ringing and aberrations.

f. Switch in the 50Ω load. The output should be cut approximately in half, with no signs of clipping.

Triangular Wave Output

1. Monitor the triangular wave output at the ⩘ BNC Connector.

   a. The output should be as follows at 10.0 X 100:

   b. The output must be symmetrical about ground and between 5 and 7 volts peak-to-peak voltage.

   c. Switch the frequency to 10.0 X 100 K. The peak-to-peak voltage must be the same (±0.3V) as in step a.

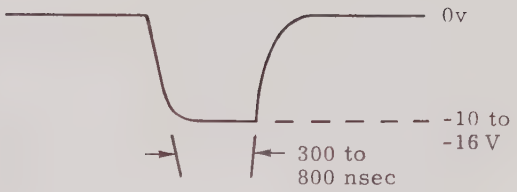
   d. The wave must be relatively free of ringing and aberrations, although some rounding in the triangle peaks will be observed.

   e. Switch in the 50Ω load. The output should be cut approximately in half with no signs of clipping.

Sync Pulse Output

1. Monitor the sync pulse output at the SYNC OUT BNC Connector.

   a. At 10.0 X 100 K, the output must look as follows:



   b. The negative pulse width must be between 300 and 800 nanoseconds.

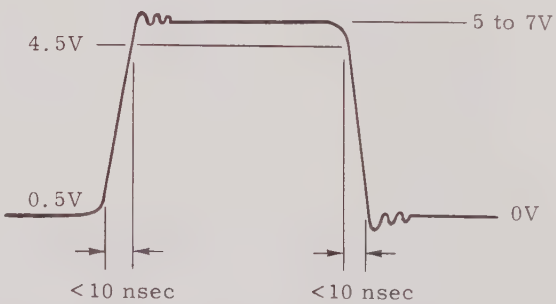
   c. The negative output level must be at least -10 volts.

   d. The positive output level is ground.

Square Wave Output

1. Monitor the square wave output at the ⊓⊔ BNC connector.

   a. At 10.0 X 100 K, the output must be as follows:



   b. The positive output must be 5 to 7 volts.

   c. The rise and fall times (+0.5V to 4.5V) must be less than 10 nanoseconds.

   d. Connect the 50Ω load. The positive output must be greater than +2.5V.

Selected Outputs

1. Monitor the signals at the OUTPUT terminal posts.

2. Select frequency 10.0 X 100.

3. Turn the LEVEL control to the extreme counterclockwise position.

4. Center the OFFSET control. Connect a jumper wire between E13 and ground.

   a. Adjust potentiometer R92 to obtain a 0 volt dc level output (±100MV).

   b. With the LEVEL control at its maximum counterclockwise position, vary the OFFSET control from maximum counterclockwise to maximum clockwise and record levels at both extremes.

   c. For maximum counterclockwise setting of OFFSET control, the dc level must be between -5 and -7 volts.

   d. For maximum clockwise setting of OFFSET control, the dc level must be between +5 and +7 volts.

   e. Remove the jumper wire from E13.

5. Return the OFFSET control to midrange.

6. Set the FUNCTION control to ∿ (sine).

7. Set the LEVEL control to its maximum clockwise position and record the peak-to-peak output level.

   a. Set the FUNCTION switch to ⋀ (triangle) and record the peak-to-peak output level.

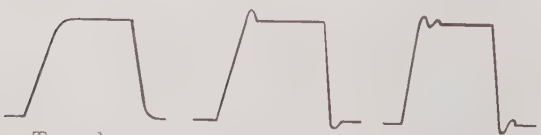
   b. Set the FUNCTION switch to ⊓⊔ (square) and record the peak-to-peak output level.

   c. The amplitudes of the sine, triangular, and square waves must be between 30 and 34 volts peak-to-peak.

8. Select frequency of 10.0 X 100 K.

9. Set the FUNCTION control to ⊓⊔ (square).

   a. Adjust capacitor C-35 for fastest rise time without significant overshoot.



Too slow Optimum Too much overshoot

   b. Ensure that rise and fall times (10% to 90%) are less than 100 nanoseconds.

   c. Ensure that this peak-to-peak output is equal to the reading in step 8 within ±1.5V.

10. Set the FUNCTION switch to ⋀ (triangle).

   a. Observe the following wave:

   b. The output should be relatively free from ringing and aberrations.

   c. Ensure that this peak-to-peak output is equal to the reading in step 8 within ±1.5V.

11. Set the FUNCTION switch to ∿ (sine).

   a. Observe the following wave:

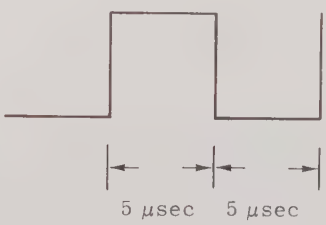
   b. The output should be relatively free from ringing and aberrations.

   c. The peak-to-peak output must be equal to the reading in step 8 within ±1.5V.

VCO Test

1. Set FREQUENCY to 1.00 X 100K.

2. Set the FUNCTION switch to ⊓⊔ (square) and monitor the selectable output.



3. Connect 5 volts output to the VCO input terminals (it is not necessary to connect

the grounds together). Observe the following selectable output:

TROUBLESHOOTING

When locating trouble in the Function Generator, start with the obvious: power source, fuse (3/4 amp, 3 AG), external short circuit loading down the output. Proceed with a thorough visual inspection. Look for burned-out or loose components, loose connections, or any other condition that suggests a source of trouble. If the visual inspection does not reveal the trouble, a systematic troubleshooting approach will prove most gainful.

Trouble can be readily isolated to a particular stage by ascertaining a proper triangular wave, since all output signals stem from the triangular wave. Consequently, the starting point of the troubleshooting procedure involves obtaining the triangular wave. This is done by setting the FUNCTION selector switch to the ∧ position and observing the signal with an oscilloscope at the OUTPUT terminal posts. If no signal is present, the same check should be made at the ∧ BNC connector.

On the basis of these checks, the next area of investigation can be determined. For example, no signals at the OUTPUT terminal posts, but a proper signal at any one of the BNC connectors would indicate that the triangular wave is being generated. Therefore, troubleshooting should be directed at the main output amplifier and the corresponding buffer amplifiers that are not producing outputs. Conversely, if no output signals are obtained, then the trouble probably exists either in the power supply, in the voltage source, or in the oscillator loop. Troubleshooting should be performed in that sequence.

Table 4-3 lists the troubleshooting procedure that may be followed to isolate trouble to a particular state. It is assumed that power supply voltages are normal. In using the troubleshooting procedure, refer to Drawing 525831 for signal waveforms that are to be observed. After observing the significant test points, perform the corresponding "a" instruction if the waveform or voltages at the specified test points are normal; otherwise, perform the corresponding "b" instruction.

For the sake of brevity, only semiconductors are listed in the "b" instructions as possible defective components. However, the possibility of failure of the other components associated with the semiconductors should not be discounted. It is possible that the failure of a semiconductor is the result of a defective passive component.

The troubleshooting table is limited to malfunctions that are most likely to occur. In analyzing other troubles, a thorough understanding of the circuits will prove invaluable. Detailed circuit descriptions and simplified schematic diagrams are contained in Section Three of this instruction manual.

PARTS LOCATIONS

The locations of all transistors, adjustments, and test points are illustrated in Figures 4-1, 4-2 and 4-3, respectively.

TYPICAL WAVEFORMS AND VOLTAGES

The waveforms and voltages given in Drawing 525831 are typical measurements found in a properly operating Function Generator. Voltage measurements are with respect to ground.

REPAIR

Once a trouble is traced to a defective individual part, replacement should be made with identical parts if practical. (Refer to Section Five, Parts List, for correct values, tolerances, etc.) When substitutions are necessary, use components that duplicate the originals in every possible respect. Avoid applying excessive heat to the printed circuit by using a small soldering iron and working quickly.

OPERATIONAL TESTS

Following repair of the Function Generator and before restoring the instrument to service, operational tests should be performed to verify proper operation of the instrument. The procedures given in the calibration and performance checks (Page 4-1) serve as an aid in verifying that adjustments or repairs made in the unit are correct and that the unit is operating properly. It is not necessary to perform all of the checks, however. Only those checks associated with the functional stages(s) that required repair need be performed.

Table 4-3. Troubleshooting Procedures

SYMPTOM	STEP	FAULT ISOLATION PROCEDURES SIGNIFICANT TEST POINT	IF NORMAL PERFORM a IF ABNORMAL PERFORM b
No output signals from OUTPUT terminal posts.	1	Observe ramp voltage at TP3.	a. Check main output amplifier: Q31, Q32, Q34, Q35, Q36, Q41, Q42. b. Proceed to step 6.
No triangular wave output from ⩘ BNC connector.	2	Observe ramp voltage at TP3.	a. Check triangular-wave buffer: Q37, Q38. b. Proceed to step 6.
No square-wave output from BNC connector.	3	Observe square wave at TP4.	a. Check square-wave buffer: Q33, Q44, Q45. b. Proceed to step 6.
No sine-wave output from BNC connector.	4	Observe ramp voltage at TP3.	a. Check sine converter: Q25, Q26, and sine-wave buffer: Q39, Q40. b. Proceed to step 6.
No sync-pulse output from BNC connector.	5	Observe square wave at TP4.	a. Check sync-pulse buffer: Q43. b. Proceed to step 6.
	6	Set FREQUENCY dial to 10; measure -11 volts dc at TP1; measure -5.5 volts at TP6.	a. Proceed to step 7. b. Check voltage source circuits: VR1, Q4, Q5, Q6, Q7, Q8, Q48.
	7	Measure -11 volts or 0 volts at TP2.	a. Proceed to step 8 if -11 volts is obtained. Proceed to step 9 if 0 volts is obtained. b. Check switch transistors: Q13, Q14.
	8	Measure from +5 to +16 volts at TP3.	a. Proceed to step 10. b. Check integrator circuit: Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24.

Table 4-3. Troubleshooting Procedures (continued)

SYMPTOM	STEP	FAULT ISOLATION PROCEDURES SIGNIFICANT TEST POINT	IF NORMAL PERFORM a IF ABNORMAL PERFORM b
	9	Measure from -5 to -16 volts at TP3.	a. Proceed to step 11. b. Check integrator circuit: Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24.
	10	Measure 0 volts at TP4.	a. Proceed to step 12. b. Check comparator circuit: differential comparator Z1(710C), Q27, Q28.
	11	Measure -8.2 volts at TP4.	a. Proceed to step 13. b. Check comparator circuit: differential comparator Z1(710C), Q27, Q28.
	12	Measure 0 volts at TP2.	a. Steps 8 or 10 were not performed correctly. Return to step 8. b. Check electronic switch: Q1, Q2, Q3, Q13, Q14.
	13	Measure -11 volts at TP2.	a. Steps 9 or 11 have not been followed correctly. Return to step 9. b. Check electronic switch: Q1, Q2, Q3, Q13, Q14.

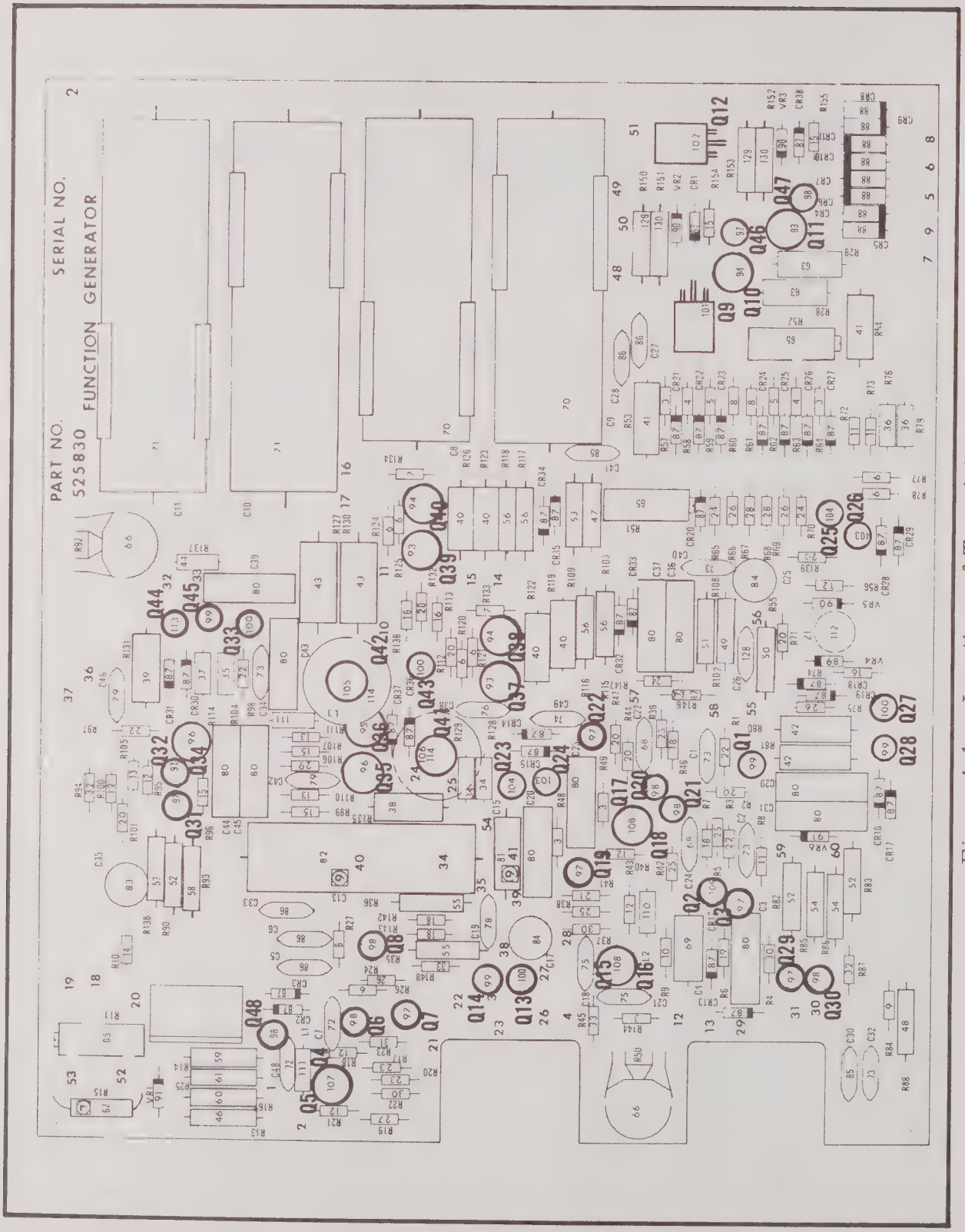


Figure 4-1. Locations of Transistors

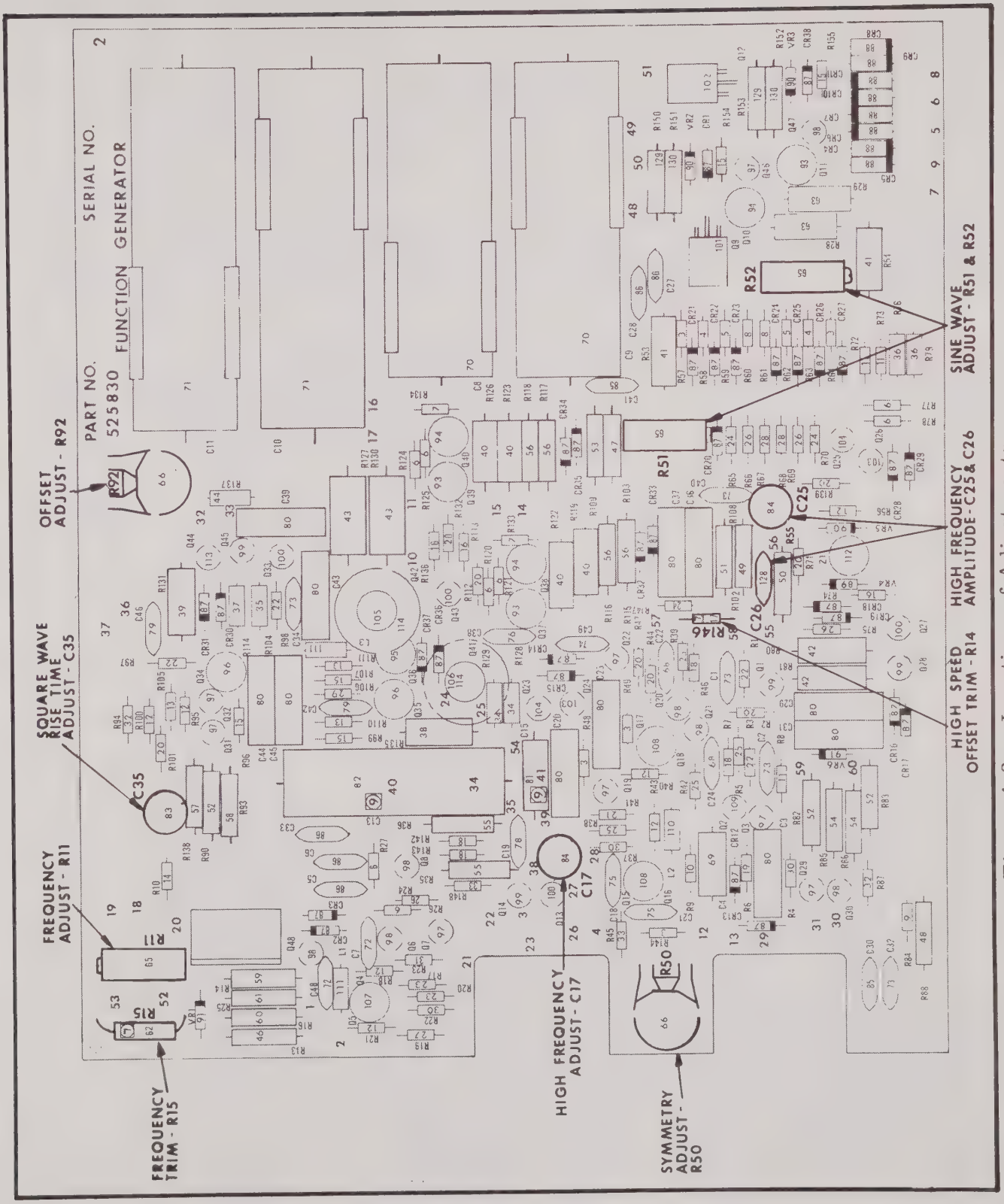

SERIAL NO.
PART NO. 525830 FUNCTION GENERATOR
OFFSET ADJUST - R92
SQUARE WAVE RISE TIME ADJUST - C35
FREQUENCY ADJUST - R11
FREQUENCY TRIM - R15
HIGH FREQUENCY ADJUST - C17
SYMMETRY ADJUST - R50
HIGH SPEED OFFSET TRIM - R14
HIGH FREQUENCY AMPLITUDE - C25 & C26
SINE WAVE ADJUST - R51 & R52

Figure 4-2. Locations of Adjustments

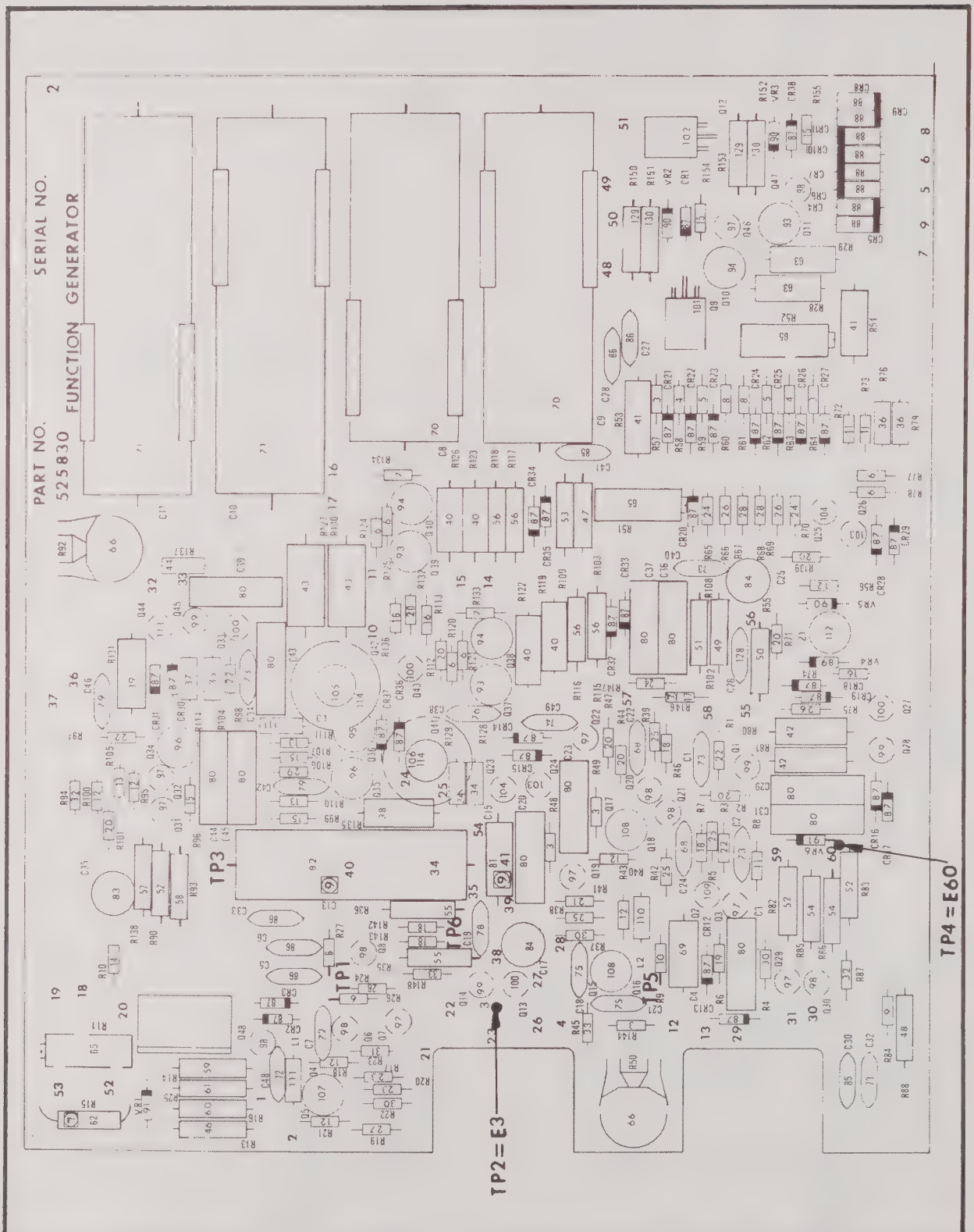


Figure 4-3. Locations of Test Points

SECTION FIVE

SPARE PARTS LIST

GENERAL

This section contains information for ordering replacement parts. Table 5-1 lists, in alpha-numerical order of their reference designators, the replacement parts of the printed circuit board. Similarly, Table 5-2 lists the replacement parts of the chassis. The parts list includes the Beckman part number, the description of the component, the vendor's part number, and the total quantity used in the equipment.

Table 5-1. Parts List, Printed Circuit Board

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
	D855-525830 (G)	Model 9010 P.C. Board	Beckman	
C1, 2, 32, 34, 40	637-825072	Capacitor, 51pf, ±5%, 500V	Sangamo D155E510J0	5
C3, 20, 23, 29, 31, 36, 37, 44, 45	651-852158	Capacitor, 0.1μf, ±10%	G.E., Type 75F	9
C4	631-841223	Capacitor, 8μf, 15V	Sprague 30D805G015BA2	1
C5, 6, 27, 28, 33	633-846524	Capacitor, 0.1μf, 20V	Centralab UK-20-104	5
C7, 48	637-822759	Capacitor, 20pf, ±5%, 500V	Sangamo D155C200J0	2
C8, 9	631-844577	Capacitor, 1100μf, 50V	Sprague 39D118G050HP4	2
C10, 11	631-846317	Capacitor, 2100μf, 30V	Sprague 39D218G030HS4	2
C12		Capacitor, Nominal Value, Selected in Test (see Appendix A)	Beckman	1
C13	651-846432	Capacitor, 5μf, ±1%, 50V	Elpac B5A505F	1
C14		Capacitor, Nominal Value, Selected in Test (see Appendix A)	Beckman	1
C15	651-846431	Capacitor, 0.22μf, ±1%, 50V	Elpac B5A224F	1
C16	637-836049	Capacitor, 160pf, ±5%, 500V	Sangamo D155F161J0	1
C17, 25	643-846449	Capacitor, Var., 15-60pf	Erie 538-011-P3P0-112R	2
C18, 21	637-825104	Capacitor, 150pf, ±5%, 500V	Sangamo D155F151J0	2
C19	637-825348	Capacitor, 300pf, ±5%, 500V	Sangamo D155F301J0	1
C22, 24	637-825467	Capacitor, 30pf, ±5%, 500V	Sangamo D155E300J0	2
C26		Capacitor, Nominal Value, Selected in Test (see Appendix A)	Beckman	1
C30, 41	637-825142	Capacitor, 390pf, ±5%, 500V	Sangamo D155F391J0	2
C35	643-857102	Capacitor, Var., 2-8pf	Erie 538-011-C0P0-89R	1
C38	637-822253	Capacitor, 200pf, ±5%, 500V	Sangamo D155F201J0	1
C39, 43	631-813760	Capacitor, 8μf, 25V	Sprague 30D805G025BA2	2
C42, 46	637-822757	Capacitor, 1000pf, ±5%, 500V	Sangamo D155F102J0	2
C47	637-825069	Capacitor, 10pf, ±5%, 500V	Sangamo D155C100J0	1
C49	637-822251	Capacitor, 100pf, ±5%, 500V	Sangamo D155F101J0	1
CR1 thru 3, CR12 thru 38	755-845049	Diode, FDH 627	Fairchild	30

. . . . continued

Table 5-1. Parts List, Printed Circuit Board (continued)

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
CR4 thru 11	755-817927	Diode, Sil., 400 PIV (Special)	Beckman	8
L1, 3	795-843986	Inductor, 150μH, 10%	Nytronics, DD-150	2
L2	795-846505	Inductor, 47μH, 10%	Nytronics, DD-47.0	1
Q1, 14, 28, 45	755-845089	Transistor, 2N4258	Fairchild	4
Q2	755-846485	Transistor, S-22079	Fairchild	1
Q3, 7, 19, 22, 29, 31, 32, 46	755-844315	Transistor, 2N3694	Fairchild	8
Q4, 5	755-851855	Transistor, Twin (Special)	Beckman	1
Q6, 8, 20, 21, 30, 47, 48	755-846594	Transistor, 2N4121	Fairchild	7
Q9	755-846422	Transistor, 2N4918	Fairchild	1
Q10, 38, 40	755-838105	Transistor, 2N3638	Fairchild	3
Q11, 37, 39	755-842018	Transistor, 2N3568	Fairchild	3
Q12	755-846421	Transistor, 2N4921	Fairchild	1
Q13, 27, 33, 43	755-857274	Transistor, 2N4275	Fairchild	4
Q15, 16, 17, 18	755-851856	Transistor, Twin (Special)	Beckman	2
Q23, 25	755-851070	Transistor, (Special)	Beckman	2
Q24, 26	755-851010	Transistor, (Special)	Beckman	2
Q34, 35	755-846440	Transistor, 2N3645	Fairchild	2
Q36	755-846439	Transistor, 2N3642	Fairchild	1
Q41	755-851412	Transistor, (Special)	Beckman	1
Q42	755-851411	Transistor, (Special)	Beckman	1
Q44	755-846740	Transistor, 2N5187	Fairchild	1
R1, 3, 97, 98	601-822527	Resistor, 1.5K	*AB CB1525	4
R2, 44, 47, 71, 101, 112, 132, 139	601-822308	Resistor, 1K	AB CB1025	8
R4, 22, 37	601-822299	Resistor, 6.8K	AB CB6825	3
R5, 38, 39, 42	601-822295	Resistor, 2.7K	AB CB2725	4
R6	601-822306	Resistor, 820Ω	AB CB8215	1
R7, 46, 142, 143	601-822369	Resistor, 680Ω	AB CB6815	4
R8, 72, 73	601-823390	Resistor, 120Ω	AB CB1215	3
R9	601-822375	Resistor, 82Ω	AB CB8205	1
R10	601-823394	Resistor, 330Ω	AB CB3315	1
R11, 51, 52	613-854382	Resistor, Var., 200Ω, .75W, ±10%	Helipot 77PR200	3
R13	607-828866	Resistor, 28.7Ω, 1/4W, ±1%	IRC, Type CEB-TO	1
R14	607-828898	Resistor, 12.1K, 1/4W, ±1%	IRC, Type CEB-TO	1
R15		Resistor, Nominal Value, 1/4W Selected in Test (see Appendix A)	Beckman	1
R16	607-855103	Resistor, 16.9K, 1/4W, ±1%	IRC, Type CEB-TO	1

*Allen Bradley - 1/4W, ±5% unless otherwise noted.

. . . . continued

Table 5-1. Parts List, Printed Circuit Board (continued)

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
R17, 20	601-822544	Resistor, 1.8K	*AB CB1825	2
R18, 21, 40, 43, 56, 95, 100	601-822327	Resistor, 220Ω	AB CB2215	7
R19	601-822297	Resistor, 4.7K	AB CB4725	1
R23	601-823391	Resistor, 150Ω	AB CB1515	1
R24, 66, 69, 75	601-822296	Resistor, 3.3K	AB CB3325	4
R25	607-828903	Resistor, 19.6K, 1/4W, ±1%	IRC, Type CEB-TO	1
R26, 27, 77, 78, 120, 121, 124, 125	601-823383	Resistor, 22Ω	AB CB2205	8
R28, 29	601-800055	Resistor, 470Ω, 1W, ±5%	AB GB4715	2
R35, 36	607-822601	Resistor, 3.01K, 1/4W, ±1%	IRC, Type CEB-TO	2
R41	601-822326	Resistor, 1.2K	AB CB1225	1
R45, 148	601-819681	Resistor, 510K	AB CB5145	2
R48, 49, 57, 64, 144	601-823379	Resistor, 10Ω	AB CB1005	5
R50, 92	614-846429	Resistor, Var., 10K, 1/4W	Mallory MTC4R10K	2
R53, 54	601-800049	Resistor, 220Ω, 1W, ±5%	AB GB2215	2
R55	607-832405	Resistor, 590Ω, 1/4W, ±1%	IRC, Type CEB-TO	1
R58, 63	601-823380	Resistor, 12Ω	AB CB1205	2
R59, 62	601-823381	Resistor, 15Ω	AB CB1505	2
R60, 61	601-823385	Resistor, 33Ω	AB CB3305	2
R65, 70, 147	601-822293	Resistor, 2K	AB CB2025	3
R67, 68	601-822298	Resistor, 5.1K	AB CB5125	2
R74, 113, 136	601-822370	Resistor, 510Ω	AB CB5115	3
R76, 79	601-015447	Resistor, 680Ω, 1/2W, ±5%	AB EB6815	2
R80, 81	601-800052	Resistor, 330Ω, 1W, ±5%	AB GB3315	2
R82, 83, 90	607-822186	Resistor, 825Ω, 1/4W, ±1%	IRC, Type CEB-TO	3
R84	601-823386	Resistor, 39Ω	AB CB3905	1
R85, 86	607-822187	Resistor, 2.05K, 1/4W, ±1%	IRC, Type CEB-TO	2
R87, 94	601-823901	Resistor, 39K	AB CB3935	2
R88	607-828889	Resistor, 383Ω, 1/4W, ±1%	IRC, Type CEB-TO	1
R93	607-825901	Resistor, 11K, 1/4W, ±1%	IRC, Type CEB-TO	1
R96, 99, 107, 154, 155	601-823395	Resistor, 470Ω	AB CB4715	5
R102	607-825511	Resistor, 511Ω, 1/4W, ±1%	IRC, Type CEB-TO	1
R103	607-825318	Resistor, 75Ω, 1/4W, ±1%	IRC, Type CEB-TO	1
R104	601-079492	Resistor, 560Ω, 1/2W, ±5%	AB EB5615	1
R105, 110, 111	601-823393	Resistor, 270Ω	AB CB2715	3
R106	601-823397	Resistor, 5.6K	AB CB5625	1
R108	607-821117	Resistor, 750Ω, 1/4W, ±1%	IRC, Type CEB-TO	1
R109	607-825890	Resistor, 1.62K, 1/4W, ±1%	IRC, Type CEB-TO	1
R114	601-008129	Resistor, 1.5K, 1/2W, ±5%	AB EB1525	1

*Allen Bradley - 1/4W, ±5% unless otherwise noted.

. . . . continued

Table 5-1. Parts List, Printed Circuit Board (continued)

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty. / Ass'y
R115, 116, 117, 118	607-822146	Resistor, 3.32K, 1/4W, ±1%	IRC, Type CEB-TO	4
R119, 122, 123, 126	601-800048	Resistor, 180Ω, 1W, ±5%	*AB GB1815	4
R127, 130	601-800123	Resistor, 150Ω, 2W, ±5%	AB HB1515	2
R128, 129	601-800005	Resistor, 22Ω, 1/2W, ±5%	AB EB2205	2
R131	601-800046	Resistor, 120Ω, 1W, ±5%	AB GB1215	1
R133, 134	601-823384	Resistor, 27Ω, 1/4W, ±5%	AB CB2705	2
R135	601-007528	Resistor, 51Ω, 1W, ±5%	AB GB5105	1
R137	601-015439	Resistor, 39Ω, 1/2W, ±5%	AB EB3905	1
R138	607-825889	Resistor, 4.64K, 1/4W, ±1%	IRC, Type CEB-TO	1
R140, 141	601-800125	Resistor, 220Ω, 2W, ±5%	AB HB2215	2
R150, 153	607-825321	Resistor, 1K, 1/4W, ±1%	IRC, Type CEB-TO	2
R151, 152	607-825888	Resistor, 1.47K, 1/4W, ±1%	IRC, Type CEB-TO	2
VR1, 6	755-832774	Diode, 1N756A	Texas Instruments	2
VR2, 3, 5	755-808119	Diode, 1N752A	Texas Instruments	3
VR4	755-851417	Diode, 3V (Special)	Beckman	1
Z1	885-843512	Integrated Circuit, μA710C	Fairchild U5B771039X	1
	776-825302	Heat Sink	IERC TXBF-032-025B	2
	864-811098	Pad, Transistor (Use with Q10, Q11, Q34 thru 42)	Milton Ross 10099	11
	864-825860	Pad, Transistor (Use with Q4, Q5, Q15 thru 18, Z1)	Milton Ross 10195-DAP	4

*Allen Bradley

Table 5-2. Parts List, Chassis

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
C50	637-822770	Capacitor, 56pf, 5%	Duramica, DM15	1
C51	637-846610	Capacitor, 2200pf, 1%	Duramica, DM19	1
C52	637-825227	Capacitor, 5pf, 10%	Duramica, DM15	1
DS1	824-846445	Indicator, Neon	Leecraft, 36EN2311	1
F1	731-029623	Fuse, 3/4A	Littelfuse, 3AG Standard	1
	735-007268	Fuse Holder	Bussman HKP	1
J1, 2, 3, 4	670-854373	Connector, BNC, UG1094/TR5	Kings KC-79-35	4
R12	611-858188	Potentiometer, 1KΩ	Helipot 5311R1KL.5	1
R30	607-846484	Resistor, 505K, 1/4W, ±5%	IRC, MEB RN65D5053D	1
R31	607-846482	Resistor, 50.5K, 1/4W, ±5%	IRC, MEB RN65D5052D	1
R32	607-846483	Resistor, 115K, 1/4W, 5%	IRC, MEB RN65D1153D	1
R33	607-846481	Resistor, 11.5K, 1/4W, 5%	IRC, MEB RN65D1152D	1
R34, 145	607-846480	Resistor, 1.15K, 1/4W, 5%	IRC, MEB RN65D1151D	2
R89	614-815826	Potentiometer, 1KΩ	Ohmite, CMU1021	1
R91	614-815828	Potentiometer, 10KΩ	Ohmite, CMU1031	1
R149		Resistor, Special (Selected in Test)	Beckman	1
S1	701-806039	Switch, Toggle	Cutler Hammer 8282K14	1
S2	B711-525859	Switch, Rotary	Beckman	1
S3	B711-525861	Switch, Rotary	Beckman	1
T1	C792-524862	Transformer	Beckman	1
TB1	691-020358	Strip, Terminal	Cinch Mfg.	1
W1	664-812450	Cord, Power, SVT, Black, 6'	Belden Mfg.	1
	661-826502	Cable, Two-Conductor	Belden 8451	1
	338-003343	Cable Clamp	Weckesser Co., 3/16-3	1
	338-064387	Cable Clamp	Dakota Eng., Inc.	1
	A325-524871	Knob, Vernier	Beckman	1
	325-846454	Knob, Pointer	Buckeye KRA7011-1	4
	216-846451	Drive, Vernier	Jackson Br. 4511 DADK	1
	B330-523775	Handle	Beckman	1
	B776-525858	Heat Sink (Used on Q10, 12)	Beckman	2

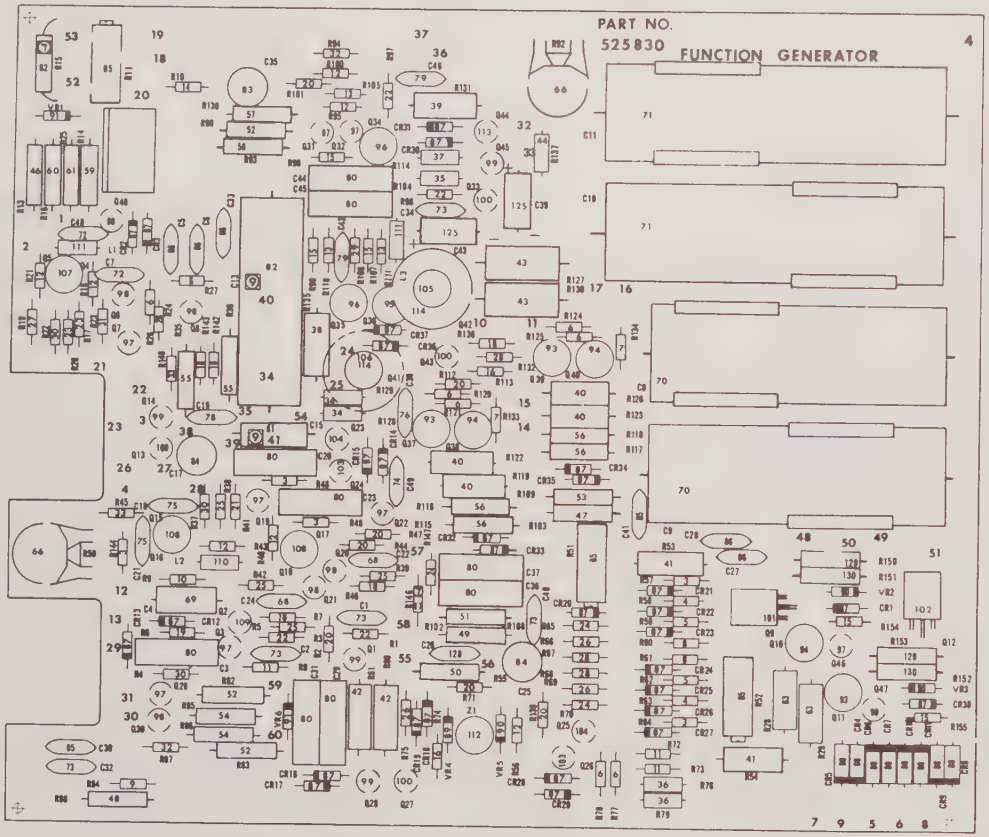
SECTION SIX

DRAWINGS AND SCHEMATICS

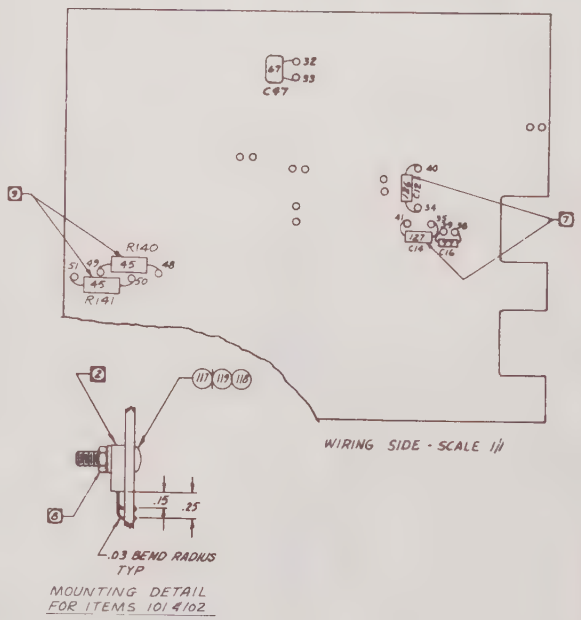
GENERAL

This section contains all schematic diagrams and drawings required for maintenance of the Model 9010 Function Generator. A list of materials is included in the assembly drawings.

Number	
525830	Circuit Board Assy Drawing
525836	Function Generator Top Assy Drawing
525831	Function Generator Schematic Diagram



REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		SEE EO 38129 (SILKSCREEN REV. 1)	7/14/67	RK/WC
B		SEE E O 32200	8-30-7	DOC PJ
C		SEE E O 32213	8-30-7	DOC / PJ
D		EO 32252 NEW DWG NO (SILKSCREEN REV. 2)	10-13-67	RK/DR
E		EO 32272 (R33 CAL CHANGE (SILKSCREEN REV 3)	11-14-67	RK/
F		EO 32273 C39 (#3 CHANGE (SILKSCREEN REV 4)	11-29-67	RK/
G		WAS 525848	3-4-68	W
H		PER ECO 32375	6-6-68	W.



MOUNTING DETAIL FOR ITEMS 101 & 102

855-525830

(D) (2) INSTALL R140, R141, C13, C15 & C16 AFTER WASH CYCLE.
(2) FINGER TIGHTEN SO AS NOT TO DAMAGE TRANSISTORS.
(D) (7) C12, C14, C26, R15 & R146 ARE TO BE SELECTED IN TEST.
6. TRANSISTORS SHALL HAVE .06 MIN TO .25 MAX SPACE OFF BOARD.
5. MAXIMUM SOLDER EXTENSION ON WIRING SIDE IS .070.
4. COMPONENT VALUES SHALL BE VISIBLE WHERE PRACTICABLE.

(2) ASSEMBLE ITEMS 101 & 102 WITH METALLIC SIDE UP.

11. USE 864-825860 TRANSISTOR PADS WITH ITEMS 107, 108, 112.
10. USE 864-811098 TRANSISTOR PADS WITH ITEMS 93-96, 105, 106.

2	R020-525831	Schematic, Function Generator	REF
1	A037 525848	Parts List P C Brd	1

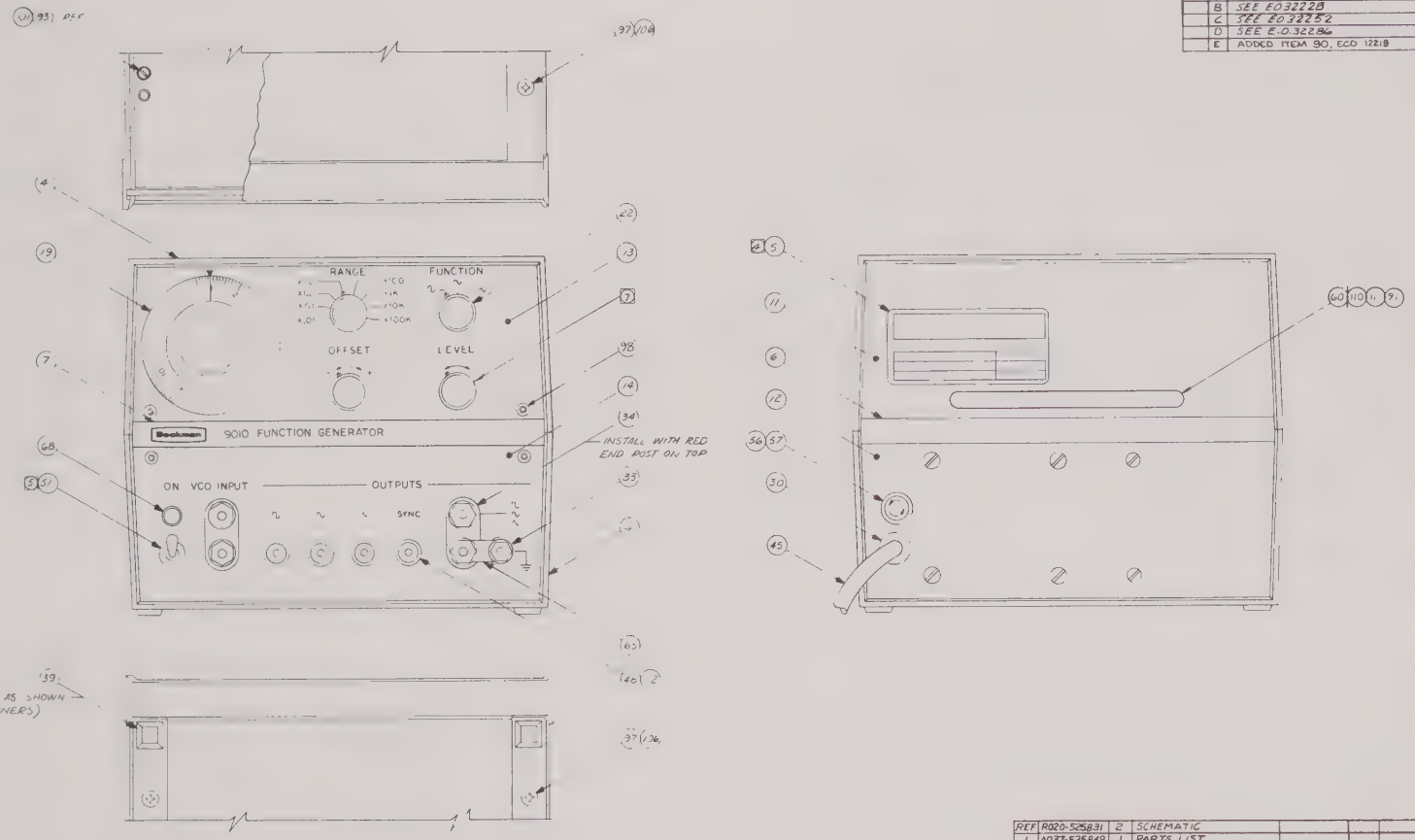
0030-525836	9010	UNLESS OTHERWISE SPECIFIED	BY / DATE
NEXT ASSY	USED ON	DIMENSIONS ARE IN INCHES	DR Hobson 6-15-67
APPLICATION		TOLERANCES	CHK Paul Peters 6-24-7
MATERIAL		X .050 ANGULAR .0 30'	ENGR
		XX .020	APPD
		XXX .005 MACH. SURF. ✓	APPD
FINISH		THREADS CLASS 2A OR 2B	
		REMOVE BURRS & SHARP EDGES .020 MAX	
		MACH. SURF. FLAT WITHIN .001 IN IN	
		OTHER SURF. FLAT WITHIN .005 IN IN	
		DO NOT SCALE DRAWING	

Beckman® INSTRUMENTS, INC. SYSTEMS DIVISION 2400 HARBOR BLVD FULLERTON, CALIF

TITLE: FUNCTION GENERATOR PRINTED WIRING ASSEMBLY

SIZE	CODE IDENT NO		
D	06110	855-525830	G
SCALE 2/1	8-629		SHEET 1 OF 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE EO32129	7/16/67	RF/WC
	B	SEE EO32220	9/12/67	CH/PD
	C	SEE EO32252	11/14/67	CH/PD
	D	SEE E.O.32286	10-5-68	PD/WC
	E	ADDED ITEM 90, ECO 12218	3/69	LW/WC



REF	R020-525831	2	SCHEMATIC				
	A037-525849	1	PARTS LIST				
QTY REQD	BECKMAN NO.	ITEM NO	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO.	CODE IDENT	MATERIAL	SPEC. NOTES SIZES, VENDORS

LIST OF MATERIALS OR PARTS LIST

(2) VALUE TO BE SELECTED IN TEST.
(7) ROTATE ITEMS 72 & 73 FULLY CCW AND INSTALL ITEM 22 WITH POINTER AT 0.01 ON PANEL.
(6) REPLACE EXISTING SET SCREWS WITH ITEM 99.
(3) INSTALL WITH 2 LUGS TOWARD 3 & 9 O'CLOCK MKR. THREADS NOT TO EXTEND MORE THAN .06 BEYOND KNURLED NUT.
(4) ATTACH NAMEPLATE PER BII STD 00-5041 LOCATE APPROX AS SHOWN.
- SET PER

(1) APPLY LACQUER PER LO-5262

FINAL	9010
NEXT ASSY	USED ON
APPLICATION	
MATERIAL	
FINISH	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
X ± .050 ANGULAR ± 0 30
XX ± .020
XXX ± .005 MACH. SURF ✓
THREADS CLASS 2A OR 2B
REMOVE BURRS & SHARP EDGES .020 MAX
MACH SURF FLAT WITHIN .001 IN IN
OTHER SURF FLAT WITHIN .005 IN IN
DO NOT SCALE DRAWING

	BY	DATE
DR	[illegible]	6-14-67
CHK	[illegible]	6-24-67
ENGR	[illegible]	6-24-67
APPD	[illegible]	6-30-67
APPD		

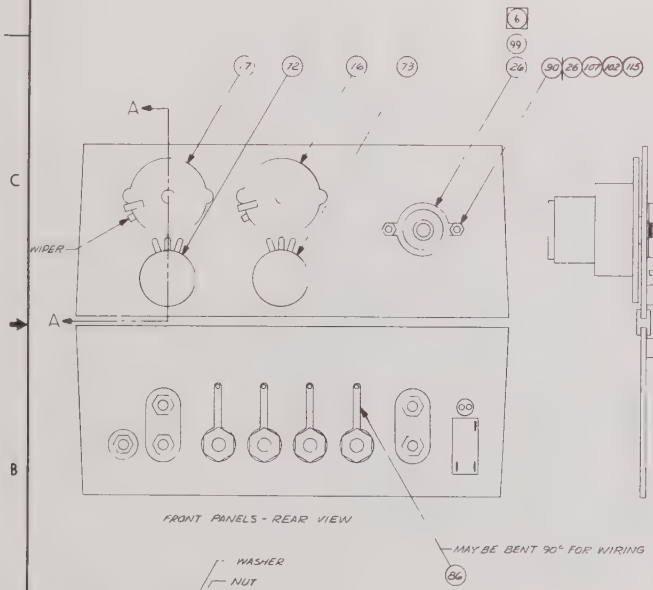
Beckman INSTRUMENTS, INC. SYSTEMS DIVISION 2400 HARBOR BLVD FULLERTON, CALIF

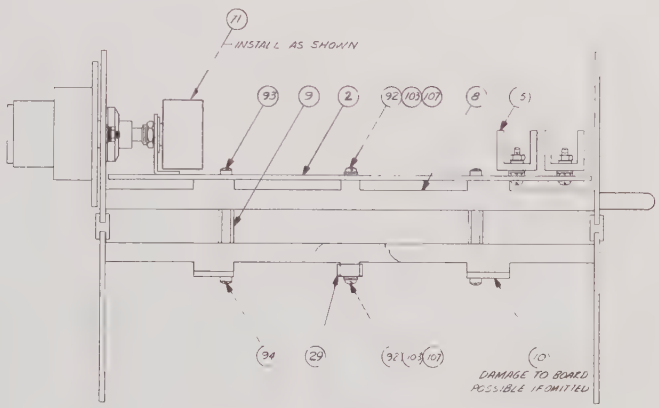
TITLE: FUNCTION GENERATOR FINAL ASSY MODEL 9010

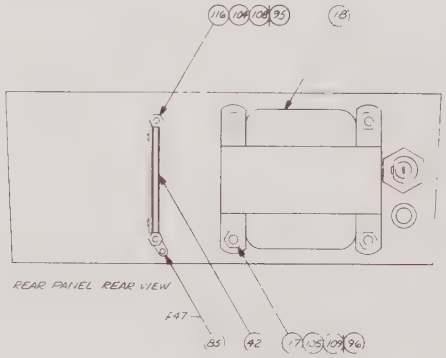
SIZE	CODE IDENT NO		REV.
D	06110	050-525836	E
SCALE 1:1	A-629	SHEET 1 OF 3	

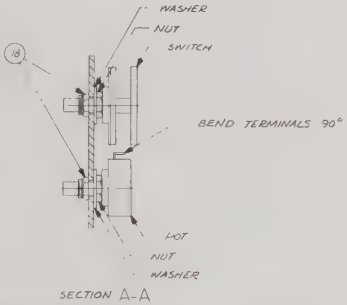
050-525826

REVISIONS			
ZONE	TR	DESCRIPTION	DATE	APPROVED









QTY REQD	BECKMAN NO.	ITEM NO.	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO.	CODE IDENT	MATERIAL	SPEC. NOTES SIZES, VENDORS

LIST OF MATERIALS OR PARTS LIST

NEXT ASSY	USED ON
APPLICATION	
MATERIAL	
FINISH	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
.X - 050 ANGULAR = 0 30'
.XX - 020
.XXX - 005 MACH SURF ✓
THREADS CLASS 2A OR 2B
REMOVE BURRS & SHARP EDGES .020 MAX
MACH SURF FLAT WITHIN .001 IN IN
OTHER SURF FLAT WITHIN .005 IN IN
DO NOT SCALE DRAWING

	BY	DATE
DR		
CHK		
ENGR		
APPD		
APPD		

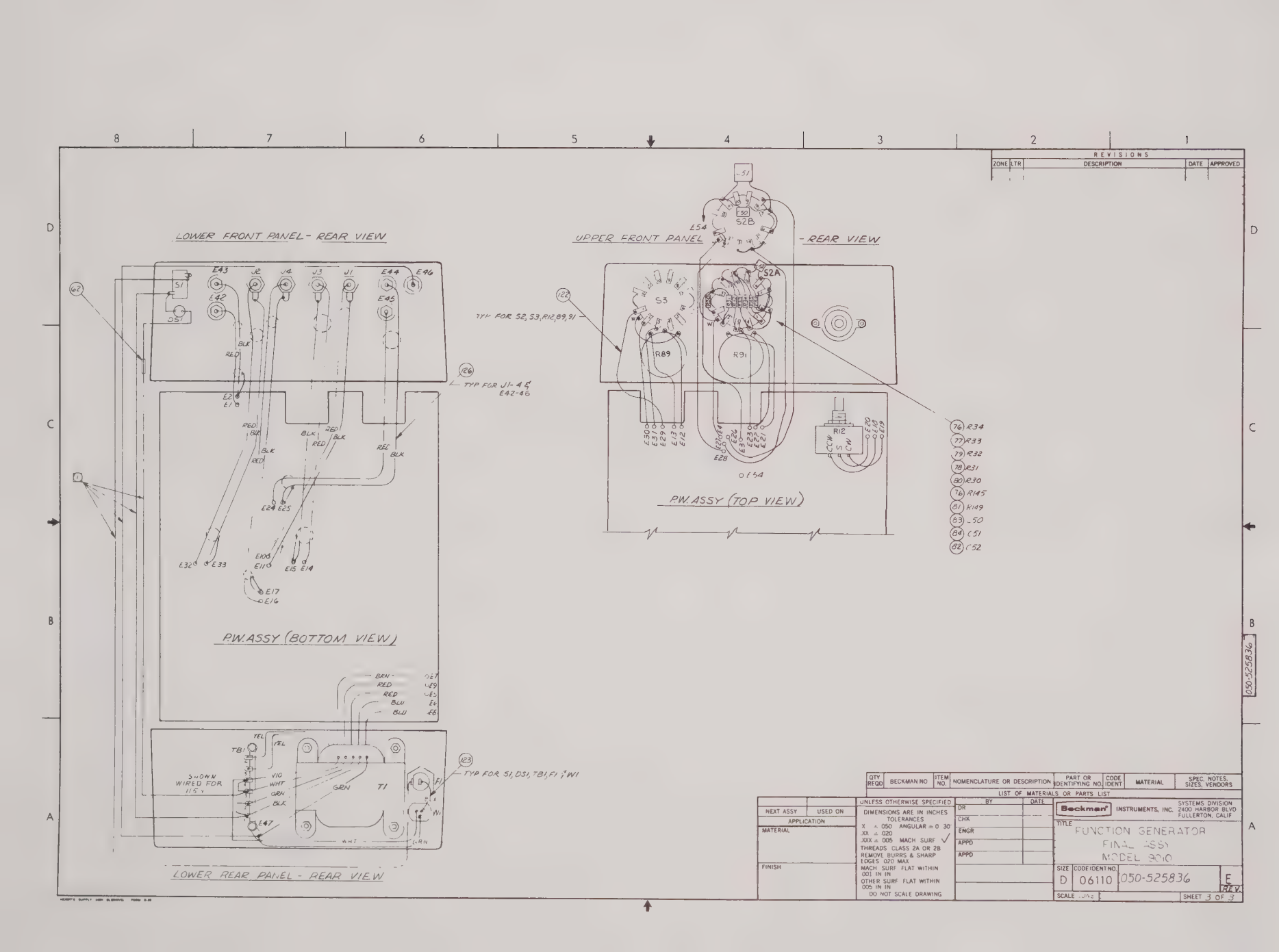
Beckman® INSTRUMENTS, INC. SYSTEMS DIVISION 2400 HARBOR BLVD FULLERTON, CALIF.

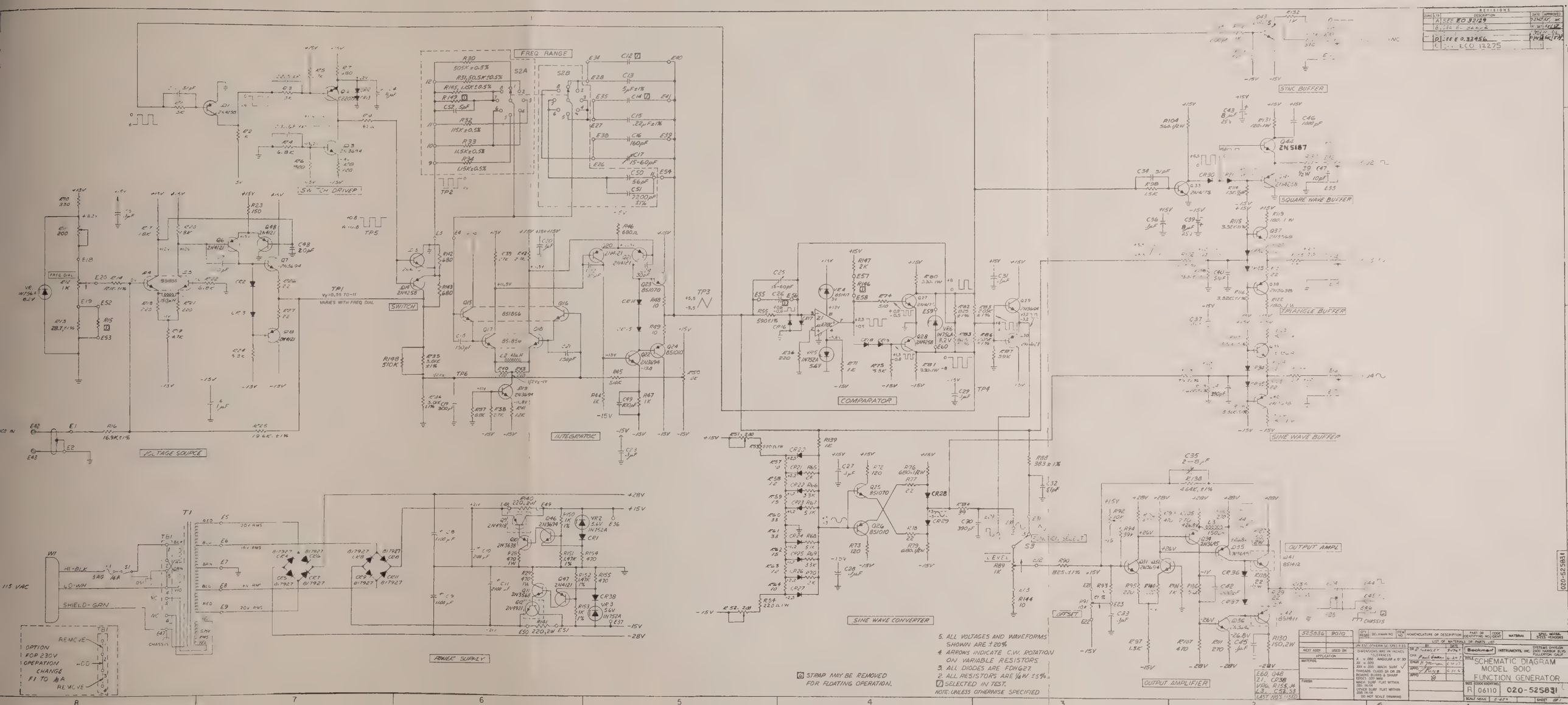
TITLE
FUNCTION GENERATOR
FINAL ASSY
MODEL 9010

SIZE	CODE IDENT NO	050-525836	
D	06110		E REV

SCALE 1/1 SHEET 2 OF 3

050-525836


LOWER FRONT PANEL - REAR VIEW
UPPER FRONT PANEL - REAR VIEW
P.W. ASSY (BOTTOM VIEW)
P.W. ASSY (TOP VIEW)
LOWER REAR PANEL - REAR VIEW
TYP FOR S2, S3, R12, R89, R91
TYP FOR J1-4 & E42-46
TYP FOR S1, DS1, TB1, F1, & W1
SHOWN WIRED FOR 115 V
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
FUNCTION GENERATOR
FINAL ASSY
MODEL 9010
050-525836
SHEET 3 OF 3


REVISIONS
DESCRIPTION
DATE
APPROVED
A SFE 80 32129
B SEE E.C.O. 32456
C ECO 12275
FREQ RANGE
S2A
S2B
SWITCH DRIVER
SWITCH
INTEGRATOR
COMPARATOR
VOLTAGE SOURCE
SINE WAVE CONVERTER
POWER SUPPLY
SYNC BUFFER
SQUARE WAVE BUFFER
TRIANGLE BUFFER
SINE WAVE BUFFER
OUTPUT AMPL
OUTPUT AMPLIFIER
SYM ADJ
LEVEL
OFFSET
115 VAC
OPTION FOP 230V OPERATION CHANGE F1 TO 1/8A REMOVE
STRAP MAY BE REMOVED FOR FLOATING OPERATION.
5. ALL VOLTAGES AND WAVEFORMS SHOWN ARE ±20%
4. ARROWS INDICATE C.W. ROTATION ON VARIABLE RESISTORS
3. ALL DIODES ARE FDH627
2. ALL RESISTORS ARE ¼W ±5%
SELECTED IN TEST.
NOTE: UNLESS OTHERWISE SPECIFIED
Beckman INSTRUMENTS, INC.
SYSTEMS DIVISION
2500 HARBOR BLVD.
FULLERTON, CALIF.
SCHEMATIC DIAGRAM
MODEL 9010
FUNCTION GENERATOR
020-525831

APPENDIX A

FREQUENCY ADJUSTMENT

Trimming capacitors and resistors are selected at the factory during test to obtain correct frequency output in accordance with the setting of the frequency dial. The procedure for selecting these components is as follows:

a. Set the EPUT counter to PERIOD measurements and select C12 (between E34 and E40) so that the x.01 and x0.1 ranges meet the following specifications:

Setting	Low	Nominal	High
10.0 x .01	9.95 Sec	10.00 Sec	10.05 Sec
10.0 x 0.1	995 Msec	1000 Msec	1005 Msec

NOTE: A mylar capacitor must be used for the trim (e.g., G E Blackhawk). A double trim may be used if necessary.

b. Select C14 (E35 and E41) so that the x1.0, x10, and x100 ranges meet the following specifications:

Setting	Low (Msec)	Nominal (Msec)	High (Msec)
10.0 x 1.0	99.5	100.0	100.5
10.0 x 10	9.95	10.00	10.05
10.0 x 100	.995	1.000	1.005

NOTE: A mylar capacitor must be used; a double trim may be necessary.

c. Monitor TP3 with a scope. Set frequency to 10.0 x 1K. DC Couple the scope preamp. Adjust the preamp gain so that the observed waveform (∿) covers the scope screen. Switch the range switch to 10.0 x 100K. AC couple the scope preamp. Adjust C25 to obtain the same peak-to-peak amplitude as previously. C26 (130 pf, between E55 and E56) must be changed if the amplitude cannot be adjusted by C25 alone. (C26 will normally be between 100 and 200 pf. Reducing C26 will increase the amplitude at 10.0 x 100K).

With frequency set at 10.0 x 100K, DC couple the scope preamp. If offset voltage exists, select R146 (between E57 and 58) until the offset voltage in the waveform is removed. R146, when used, should be a 1/4 watt 5% resistor.

Recheck the amplitude and offset of TP3 (scope DC coupled) at 10.0 x 1K and 10.0 x 100K and ascertain that they are the same at both settings.

d. Set range to 10.0 x 10K and counter to EPUT. Select R149 (1/4w, 5%) (on range switch S2A, pins 7 and 12) for the following specification.

Setting	Low	Nominal	High
10.0 x 10K	99.5 kHz	100.0 kHz	100.5 kHz

NOTE: R149 should be greater than 20K.

e. Set range to 10.0 x 100K, with counter on EPUT. Adjust C17 for the following specification.

Setting	Low	Nominal	High
10.0 x 100K	995 kHz	1000 kHz	1005 kHz

Beckman

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